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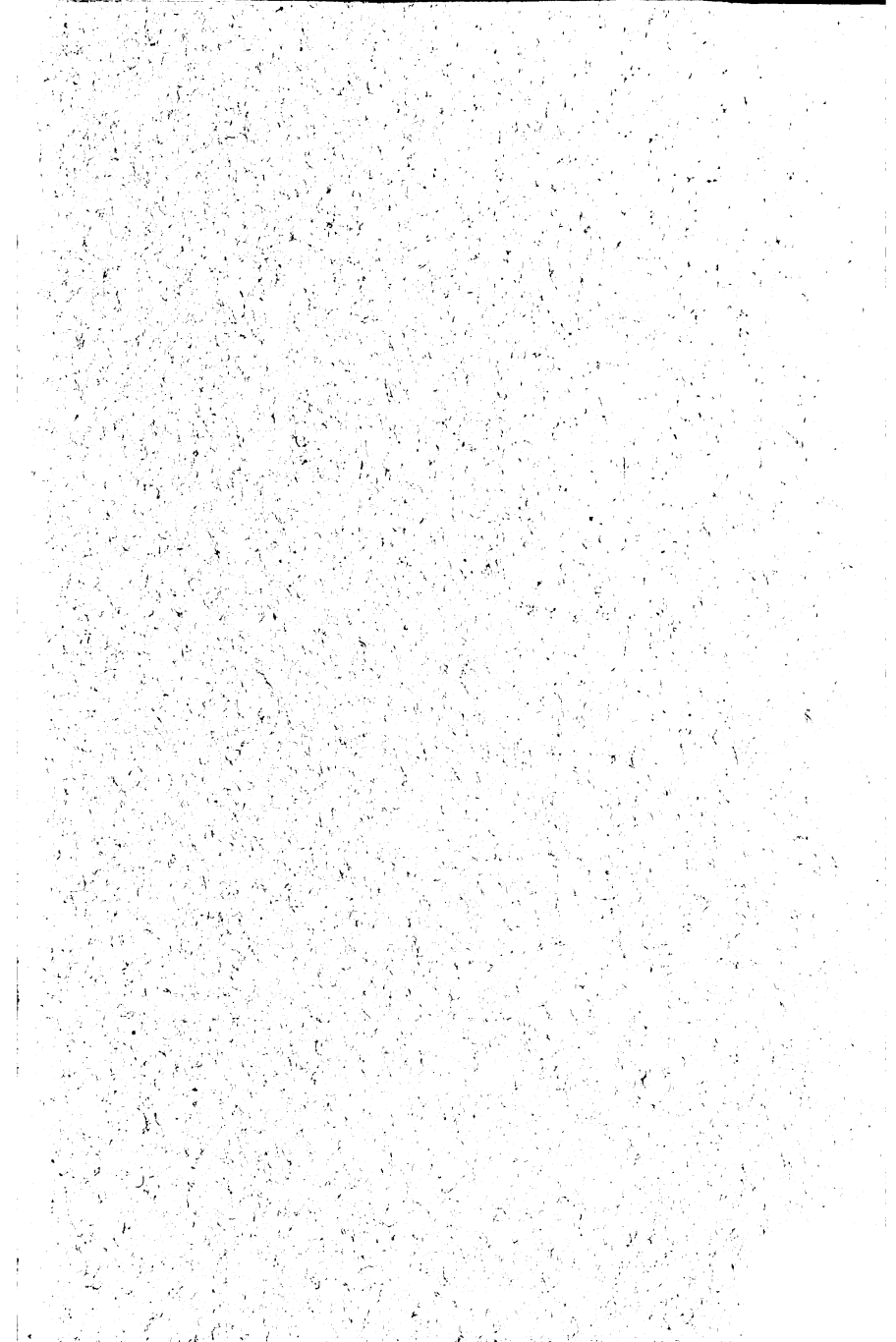
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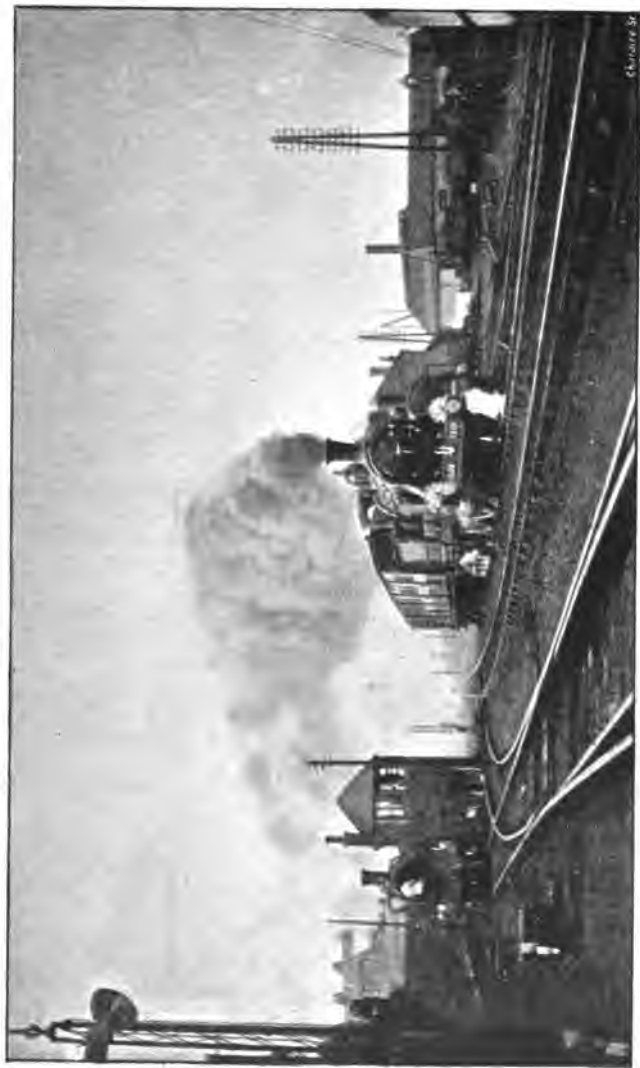
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THE CALEDONIAN MAIL TRAIN.
(From a photograph by Dr. T. F. Budden.)

EVERY-DAY LIFE

ON

THE RAILROAD

BY

W. J. GORDON

AUTHOR OF 'THE STORY OF OUR RAILWAYS,'
'FOUNDRY, FORGE AND FACTORY,' 'HOW LONDON LIVES,'
ETC.

SECOND EDITION, REVISED

THE RELIGIOUS TRACT SOCIETY

56 PATERNOSTER ROW, AND 65 ST. PAUL'S CHURCHYARD

1898

P R E F A C E.

THIS book is, in the main, composed of the series of articles which appeared in the *Leisure Hour*. They have been extended and brought up to date ; and I take this opportunity of thanking the many leading railway men to whom I am indebted for the facilities afforded, not only in their preparation, but in their revision. For the illustrations on pages 2, 38, 78, and 158, I am indebted to Mr. F. Moore, of 6, South Place, Finsbury.

W. J. G.

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THE TIME-TABLE.

EVERY-DAY LIFE ON THE RAILROAD

CHAPTER I.

THE TIME-TABLE.

IN this island of Great Britain there are over 18,000 miles of railroad ; and on these 18,000 odd miles there are carried in the course of a single year over 350 million tons of minerals and merchandise ; and a number of passengers equal to more than half the population of the earth. To carry these passengers and goods there are some 40,000 carriages, and over 600,000 other vehicles, dragged by 18,000 engines, which together travel in the course of the year about 350 million miles, or nearly four times the distance from the earth to the sun.

The handling of this enormous mileage with the minimum of accident is an ordinary achievement of which we make but little boast, regarding it as hardly worth notice. But nothing like it was known before, and the Roman with all his roads would have looked upon it with amazement.

This mention of the Roman suggests a common allusion we may as well deal with as we go. How often we

hear of the roads of the past as better than those of to-day! Why, say the antiquarians, cannot you make as good a road as the Romans? Even admitting the very doubtful inferiority, the answer is complete. The roads of our age are the railroads. It is by them that the traffic of the country goes; our parish roads are but their auxiliaries. The comparison should not be between Roman roads and parish roads, but between Roman roads and railroads. And nowhere in the present or the past can there be found a better road than an English railway line, running at easy gradients through hill and over valley, and perfect in construction in every inch of its course. A comparison of the Appian Way with the London and North-Western, of the roads in Gaul with the competing lines through Cumberland, is certainly not to the advantage of the ancients, wonderful as their work was, considering the conditions with which they had to deal. As in all things else, the modern holds the field. Even the Pyramids of Egypt could be surpassed, if the way were clear for a dividend.

And this brings us to the money question. To make and work our 18,000 miles of line there has been invested as capital over a thousand millions of pounds, a sum exceeding our National Debt by 430 million pounds! If ever the Government become possessed of the railways, as many people hope, a nice little amount will be required. A thousand million pounds, whether alive or dead, is not the sort of thing the British taxpayer would care to part with in a hurry. At $4\frac{1}{4}$ per cent.—the present average railway dividend—the profits would, of course, help considerably to pay consols interest at $2\frac{3}{4}$; but the magnitude of the financial operation will keep it for some time beyond the range of practical politics, and the longer it is so kept, the nearer the arrival of the

means of locomotion to which the railways will in their turn give place.

But we can leave the future to take care of itself. This is the railway age. The work done on the line has an interest for every member of the nation. It exercises a powerful influence on the food we eat, the clothes we wear, the houses we live in, the streets we tread, and the thoughts we think.

Taking personal travel first, we find that, on an average, every man, woman, and child in Great Britain takes a railway journey every fortnight. How the millions tell up! In the course of a year the Great Eastern Company conveys nearly 97 millions of passengers; the Metropolitan carries 76 millions, the London and North-Western 73 millions, the Great Western 70, the London and South-Western 56, the Lancashire and Yorkshire $52\frac{1}{2}$, the Brighton $50\frac{1}{2}$, the North-Eastern 47, the Midland 45, the District 41, and the Great Northern, North London, Chatham, and South-Eastern each from 32 to 37. These are the fourteen chief passenger lines, and among them they account for 745 million travellers.

To estimate the weight of the people is a trifling task we leave to others; compared to the weight of the goods and minerals, it is insignificant. In a year the North-Eastern carries 46 million tons of minerals and ordinary goods, the London and North-Western carries 39 million tons, the Midland 34, the Great Western 31, the Lancashire and Yorkshire $19\frac{1}{2}$, the Great Northern 14; and thus our six largest carriers account for 184 million tons.

The distances these weights are carried are as remarkable. In this island there are five companies with over a thousand miles of railroad apiece. Of these the Great Western trains run 41 million miles on 2,542 miles of

line, the North-Western run 43 millions on 1,909 miles of line, the North-Eastern run 29 millions on 1,630 miles of line, the Midland run 42 millions on 1,397 miles of line, and the Great Eastern run 19 millions on 1,105 miles of line.

But enough of big figures. Suffice it to say that the 18,000 miles of line are traversed over 18,700 times in a year, the total mileage amounting to 337,000,000. In other words, there is more than the equivalent of a train every half-hour day and night on every mile of line.

How is it that in so small an area as our railway system 350 million tons can be run hither and thither for nearly as many million miles without frequent disaster? How is it that this huge traffic is carried on with so little danger, that it is actually safer to ride in a railway carriage than to walk to a railway station?

The answer is 'Time!' By the time-table the trains come on to the line at workable intervals, and by the time-table they more or less punctually come off it. The signalmen take them in hand as they run, and secure them a safe position, but the main cause of their safety throughout is their keeping time. Would they could keep it better and eliminate accident altogether!

Who made the first railway time-table is not clear. In the early days of railway history, the tables were way-bills like those of the coaches, one bill for each train. The arrangement in columns came in tentatively and gradually, but its originator is undiscoverable. For many years it was the only method adopted both before and behind the railway scenes; but now a diagram system has been introduced for the use of the officials, which some day may even come before the public. The advantages are great. Though somewhat complicated at first sight, it is clearness itself when understood. Let us give a few

minutes to this diagram, and have a little practice in 'stringing the trains,' just by way of making the modern method intelligible.

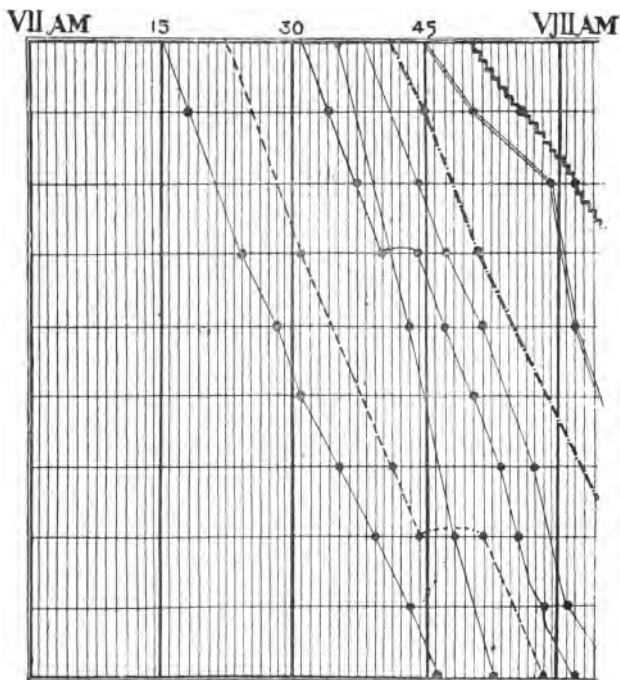
Let us pin a sheet of paper on to a drawing-board : and, leaving a margin, divide it into twenty-four equal parts. Through the divisions we draw parallel vertical lines, and have thus a vertical space for every hour of the day. Let us further divide each space into half-hours, quarter-hours, five-minute intervals, and even minute intervals, if our paper will permit us ; and let us number our first lines from midnight to noon, and on to midnight again, so as to have what by joining the right and left edges would be a cylindrical clock face.

Now let us divide our marginal line into just as many spaces as there are miles in the line over which we intend to run our trains ; and at the proper points on this vertical scale let us write the names of the stations through which our train will pass. We have thus a vertical scale of distance, and a horizontal scale of time.

As our example, let us take the trains from Victoria to the Crystal Palace. The first starts at a quarter past seven in the morning. Where the horizontal line from Victoria crosses the vertical line from 7.15 we insert a pin ; at 7.18, where the line from Grosvenor Road crosses the time line, we insert another pin ; as the train does not stop at Battersea Park, our next pin will be at 7.24 at Clapham Junction ; our next at 7.28 will be at Wandsworth Common ; our next at 7.31 at Balham ; our next at 7.35 at Streatham Hill ; our next at 7.39 at West Norwood ; our next at 7.43 at Gipsy Hill ; our next at 7.46 at Crystal Palace. Now let us join all our pins by a coloured thread, and let us mark out all the trains of the day on the same plan.

When the trains do not stop at a station the threads will cross the line at the time the trains run through.

The ordinary passenger working is thus shown at a glance. Let us plot out the mineral trains in the same way with another coloured thread; let us show the goods trains in the same way with another coloured thread; if there are any 'foreign' trains from other lines, or any



THE STRINGING-BOARD.

special goods trains, such as fish trains, etc., we mark them with a different-coloured thread; and so on until the complete day's traffic passing over the down line is shown. If a train has to wait for some minutes at a station, two pins will be used and the thread will be straight between

them. Having the trains on the road throughout the day thus displayed, it is obvious that the position a special train or excursion train can be made to occupy is at once discoverable. If a train is to be accelerated or slowed, a shifting of the pins will show how it can be done. If it is to pass another at any station, it must be so arranged as to pass through where the thread from pin to pin is horizontal.

By 'stringing the trains,' the risk of collision is minimized ; until the device was hit upon, dependence had to be placed on figures : now it is placed on diagram, and mistakes are immediately apparent. Some years ago there was a man at a certain terminus who knew the position of every train at every moment at every point of the line. 'Where is the 3.30 now?' we would ask. 'The 3.30, sir, is now just passing the two oaks on the left-hand side of the White Horse cutting—or rather, it ought to be if all is well.' The man was a wonder. He made it his business to master this curious problem of localization. He was a walking Bradshaw, and something more ; but now his feats of memory are easily acquired by means of the board and strings, or rather two boards, for as a rule there is one board for the down traffic and one for the up, each board being about four feet long by half as wide.

The making of a railway time-table is, however, no easy matter. In the winter the goods traffic is heavy and the passenger traffic light ; in the summer the goods traffic is light and the passenger traffic heavy ; hence it is that the chief alterations are made in spring and autumn. But every month of the year there are changes in both goods and passenger running, and a change in the time of even a single train may mean dozens of changes in the time of connecting trains it communicates with on its course. 'A train service,' as Colonel Findlay says, 'is like a

house of cards: if the bottom card is interfered with, the whole edifice is disarranged and has to be built up afresh. Remembering all this, and the pressure under which the work must be done, the wonder is not so much that an occasional error creeps into the time-table as that such marvellous accuracy is, on the whole, arrived at.'

There are many things to be thought of. To begin with, the trains must be equal to the traffic, and they must not only be got away from the terminus, but brought back again within reasonable hours. As the conditions change, the alterations are made according to suggestions from the staff or outsiders, and the result we see in the difference between a time-table of to-day and one, say, of ten years since.

On many of the lines a report is drawn up setting forth the trains it is proposed to alter, or to abolish, or to add. This is submitted to the general manager and then to the directors, for the change of a train on one line may mean the change of many on friendly or rival lines, and thus have an important bearing on railway policy. After the report is considered, the alterations authorized are made in a copy of the current tables, and all the times at all the stations affected are carefully examined and checked, so that none of the existing working is thrown out of gear. The type of railway tables is always kept standing, and when the printers receive the copy for the coming month, all they have to do is to make the corrections. After passing a very careful routine of official revision, the proofs are dismissed and the copies struck off.

The variety of tables used by a great line is considerable. There are first the sheet tables. These are the tables that ought to be among the most prominent decorations of railway station walls, if only the advertising

fever would leave us in peace. As it is, they have to be picked out from a mass of very miscellaneous matter, and are generally placed in such badly-lighted positions that a match has to be used at night to read them by. Another peculiarity of these tables is that they are seldom found on the outside of country stations; the would-be passenger arriving before the station is opened being generally unable to ascertain when business will begin, owing to the table being exhibited either in the locked booking-office or on the inaccessible platform. Surely on a railway, where so much depends on time, the easiest thing to find inside and outside should be the time-table.

Besides the sheets there are the books which all the chief companies have on sale. The Midland print some 40,000 copies of theirs, which are sold to the public at a penny, though they cost nearly fourpence. All companies lose money in the same way, more or less, but the loss on the book is a working expense which cannot well be abolished. These books and sheets are the authorities for the private guides and local tables, of which there are so many in the market. As soon as the proofs are passed for press, duplicates are sent off to Bradshaw and others, and these people make their corrections, and start printing a few hours after the official printers, so as to be ready on the first of the month. In return for the proofs the first copies of the guide are usually sent to the railway company, and in some cases as a matter of favour these are looked over and attention called to mistakes. But this is in no case done as a matter of right, it is simply considered to be worth the time, to save from annoyance such of the public as prefer the local guide to the official time-book.

On the North-Western the time-tables are discussed at the Officers' Conference in the third week of every month,

and the changes are then ordered. To revise the existing tables, there then proceed to the printers at Newton-le-Willows a 'time-table clerk' from each of the ten districts into which the line is divided, and a representative of the Superintendent of the Line to supervise their labours. Each of the clerks writes out the times for his own section, and when these are all settled, the proofs are corrected on the spot, so as to avoid delay in transmission.

But let it not be supposed that the sheets and cards and the penny or twopenny time-tables of the passenger service are the only ones required. Besides these there is the 'working time-table' for the use of the company's men, which, on a 'heavy' line, forms a good-sized volume of three or four hundred pages. In it are given not only the times of running the mineral and merchandise trains, and the stations at which the waiting and shunting are to be done ; but also the times of every train on the line, at every station it stops, and every principal station it passes through without a stop. This is *the* time-table to look at. If the judge were correct in ascribing lunacy to any man who studies Bradshaw for twenty consecutive minutes, the men who work our railways must be in a bad way indeed. Here are all the details, up and down, of the newspaper trains, the mail trains, the expresses, the fasts, the stopping trains, the local trains, the express goods, the stopping goods, the coal trains, and trains unclassified : all duly set forth, so that every man concerned in the working of each train must read and learn what his share in that working is to be. Special trains decided upon during the month have, if time permit, special leaflets to be added to this bulky time-table ; and if the Queen should come, there will be an extra pamphlet of half a dozen closely-printed pages, giving the time of the royal train past every signal-box from end to end of the road on which it runs.

This royal train would be the finest train in the world if it would only go a little faster. But while ordinary people are in these days carried to the north at a speed of fifty miles and more an hour, the Queen is content to jog along at an old-fashioned thirty-six. Were it not for the 'stringing,' the interruption to traffic caused by this leisurely progress would be serious. A pilot-engine runs a quarter of an hour in front of the train, to make sure of a clear line. For half an hour before the train passes a signal-box, no engine or vehicle is allowed on the section of the line under the signalman's control. For half an hour no train can cross that section of line, nor can any shunting take place on the lines adjoining it. And after the train has passed nothing is allowed to follow for a quarter of an hour. Further, on the lines alongside, no engines or trains except passenger trains are allowed to travel between any two signal-boxes from the time the pilot is due until the train has passed. Every station and crossing is guarded to keep trespassers off the line. All the facing points are bolted, so that the train cannot run on to the wrong line; all level crossing gates, when there are no gatekeepers, are locked an hour before the train is due; all along the line platelayers are on the watch to keep the road clear, and on the train itself there are fitters, lampmen, and greasers, alert for any eventuality. No wonder that the working of a train like this requires a pamphlet to itself.

With the gold-printed time-table prepared for the Queen there is given a card showing the gradients of the road. If this were done with other time-tables, many of the mysteries of travel would be made plain. Great is the effect of gradient on velocity; a rise of only 1 in 224 requiring twice the engine-power that the level does. The object of the surveyor is to secure a level road, and consequently the older the road the more level it is. It

is the newer road which is hilly and picturesque. The Great Northern road to Scotland is fairly level : so to a less extent is the North-Western ; but the picturesque Midland is far more up and down, and the engine-power used in accomplishing the distance in anything like the time of its rivals is necessarily great ; in fact, there is no better work done in the railway world than by the Midland Scotch expresses. During the railway race to Edinburgh the most amusing feature was the crowd of old ladies placidly taking their seats at St. Pancras, congratulating themselves on having avoided the wild antics of the Northern Scotchman and Flying Nor'-Wester. 'So dangerous, you know, with their sixty miles an hour.' The sixty miles having been fled from, in order that the timid ones might all unknowingly be dragged up the banks of the Waverley route at a laborious forty, and hustled down them at an exhilarating seventy-five. It was indeed a case of ignorance being bliss, particularly in the neighbourhood of Blea Moor.

On a straight and level line punctuality is easy ; but on a curved and hilly one the difficulties increase rapidly. The effect of a gradient on a train is nowhere more clearly shown than at the Hopton incline on the High Peak Railway, where there is a gradient a quarter of a mile long rising 1 in 14. Up this an engine is just able to draw its own weight of load, and no more. Increase the load ever so little, or let the rails be slippery, and locomotion there is none. This is an extreme instance, but a clear example. Sudden changes of weather, and unexpected rushes of passengers and luggage, make but little difference on the dead level ; it is on the 'banks' that the engine feels them, and minute after minute is lost.

But the time is made up on the down grade ? That is difficult. Let us work out a little sum together. A train

travelling sixty miles an hour has to slow to thirty miles an hour in ascending an incline, say, ten miles long. On the flat she would have accomplished the ten miles in ten minutes; but as she has to slow to half speed, it takes her just double that time to reach the summit, and consequently she loses ten minutes by the ascent. How can she regain this? Take her down the incline at the terrific rate of even ninety miles an hour, and yet she will fail to make it all up. For at ninety miles an hour it will take her forty seconds to do each mile, or six minutes forty seconds to do the ten miles, which on the level she would have done in ten minutes. She therefore loses ten minutes on the ascent, and gains only three minutes twenty seconds on the descent, and thus the gradient means a loss of six minutes forty seconds. In nothing is the value of lost minutes more apparent than in railway working.

To keep the loss at a minimum, the margin of power in an engine has to be a wide one. A rise of 1 in 112 trebles an engine's work; one of 1 in 75 quadruples it; one of 1 in 56 multiplies it five times. If an engine requires 150 horse-power to drag a train along the level, it will have to develop 900 horse-power to drag the same train up an incline of 1 in 45. The sharper the rise, the sooner is felt the effect of a slippery way or an increased load. In this we have the reason of the constantly varying speed at which our long-journey trains are driven, and the reason why between any three stations, at equal distances, the time of the journey differs.

As the engine has a margin of power, so the timetable allows the train a margin of time; but it is obvious that this cannot be very wide without disorganizing the traffic throughout the line. Even were trains to be worked entirely by signal, they would still have to start and arrive at definite hours.

The drawing up of the time-table is consequently not the easy matter it would at first sight seem to be. The state of the trade, the state of the road, the state of the steam-power, and a hundred other things, have to be taken into consideration, and the result is a compromise.

Sometimes there is a vested interest which has to be respected, and acts as a worse retarder than even a high gradient. Take Swindon, for instance. When the Great Western opened, it was supposed that as a man was hungry after travelling seventy-seven miles by coach, so would he be hungry after seventy-seven miles by train. The difference in the time of the journey was forgotten by the maker of the time-table, and the Swindon stop then introduced, with the ninety-nine years' lease of the rooms, was for years the great obstacle to improvement in the Great Western running—so the Great Western people said. A similar mistake was made at Wolverton on the North-Western, but there, in the absence of a lease, a clearance was effected as soon as the traffic required it. At Wolverton the passengers from Birmingham to London were expected to dine, but the passengers discovered to their astonishment that they were never so hungry as they expected to be, and the Wolverton meal lost patronage. Nowadays, passengers dine at much longer radii, not at Swindon and Wolverton, but at Preston, and Normanton, and Doncaster—that is, if they do not take their meals on the journey in the dining-car—and the stop at Wolverton is as much a thing of the past as that at Newton on the Liverpool and Manchester, where all trains were detained ten minutes in order that passengers might 'refresh themselves with Eccles cakes!'

CHAPTER II.

IN THE BOOKING-OFFICE.

TAKE a sheet of pasteboard as large as Hyde Park, cut it up into slips an inch and a quarter wide and two and a quarter inches long, and you will have rather less than the number of railway tickets used in this island during the last twelvemonth. Put the slips end to end, and you will have a ribbon that will reach right round the world.

The year 1891 was the jubilee of the railway ticket. But we are so accustomed to 'consider the existing as the original that we require an effort to realize a pre-ticket period. It seems as remote from us as the days of barter from those of pounds, shillings, and pence.

A clerk will 'book' 800 passengers an hour; in the days when he had really to book them, to write their names in a book, he would have thought the 800 a good day's work. The saving of labour has been enormous, and, unlike most inventions, the ticket remains much as it was at first. It is still numbered and dated, as it was then; and its only changes have been in colour and the words printed on it.

In 1839 an ingenious Friend who had failed in business had obtained a situation as booking-clerk on the Newcastle and Carlisle Railway. He had to book the

passengers as the passengers were booked for the old mail-coaches—that is, to write out their names in full, fill in particulars of the date and station and class, and tear off the ticket from a printed sheet. It was a very natural arrangement, but cumbrous, and one day as he was walking in a certain Northumbrian field, and reached a certain spot in that field—the spot being known to this day—an idea occurred to him of quite another ‘spin down the ringing groove of change’ to that to which he was accustomed.

‘Why all this fumbling and spelling of people’s names? Why not treat them anonymously and number them? Why not a strip of stiff paper, of pasteboard, printed with names of stations and class, consecutively numbered for accounting purposes, and dated on the day of issue to prevent fraud? Two machines could do it!’

And off went Thomas Edmondson to think it over with his friend Blaylock, the watchmaker; and together they made the first machines. But to get the new system introduced was not easy. The Newcastle and Carlisle directors would have nothing to do with it; they were content to leave well alone; and they left it, with a view of profiting by other people’s experience. Edmondson had to look elsewhere, and soon secured two strings to his bow—a short one near home, and a longer one. The short one was a part of the Manchester and Leeds line, on which he was permitted to give his invention a trial; the longer one was in the West.

On Midsummer Day, 1840, there was opened what is now a portion of the Midland system, the line between Bromsgrove and Cheltenham. This was a part of the old Birmingham and Gloucester, famous among English railroads as having been the first to get its Bill through Parliament in the first year of application. At the outset it was a forlorn hope amongst railways. Its shareholders

were obtained by months of canvassing, and great was the joy whenever a share was sold. The engineer was engaged on the curious terms of 'no success, no pay!' and in order to keep down the expenses of opposition the line was taken well out of range of assault from the magnates of the towns on the road. It was this consideration which took it a mile and a half from Cheltenham and straight up Bromsgrove Lickey.

Bromsgrove Lickey is the steepest gradient on a main line in this island. It rises 1 in 37 for two miles; and yet, unlike all other steep inclines on the older roads, it has always been worked by locomotives. Brunel and George Stephenson said no locomotive could get up it; and in days when it was thought inevitable that there should be stationary engines to drag the trains up out of Euston and Liverpool, it was not a little startling to find an engineer stoutly declaring that up the Lickey he would send his train, and ropes he would have none. And up he went; but even to-day so great is the effort that in ascending the gradient an extra engine has to come behind the train and push, while the front engine pulls its hardest; an arrangement which necessitates the keeping of five engines to do nothing but this 'banking,' at a cost of something like £1000 a year apiece.

All the same, Brunel and Stephenson were correct within a certain limitation. By 'no engine' they meant 'no existing English engine.' But Captain Moorsom had been in America, where he had seen engines go up even sharper gradients, and it was with American bogie engines, having driving wheels of only three feet, that he drew his first trains up the Lickey. These engines have long been superseded, the last of them used to be on the Tewkesbury branch—which was at first worked by horses—but they are worth remembrance. They were not the first bogies, for the bogie was invented on this side of the

Atlantic, and there were bogie engines on the Dundee and Newtyle line as early as 1833.

Now an engineer who could work on the 'no cure, no pay' system, who had enterprise enough to run a railroad up the Lickey, and pluck enough to put American engines on the line, was evidently the sort of man to welcome something new in booking. And so to him did Edmondson apply, with the result that a ticket-rack was set up at Bromsgrove and at all the other stations to Cheltenham by the old road which went to the east of Worcester. The terms for the use of the invention were half a sovereign per mile of road per year; and at these terms, other companies rushing in where the Manchester and Leeds, and Birmingham and Gloucester had not feared to tread, Thomas Edmondson soon grew rich. But an honest man was Edmondson as well as an ingenious one. As soon as he had the funds he called his old creditors together, and paid his debts in full, and then with a clear conscience he resigned himself to live on his royalties, find other uses for his money, and make many a pilgrimage to the spot of earth on which he had conceived his happy idea.

He had a brother, a distinguished schoolmaster, who, being also a railway-minded man, was progressive enough to introduce the study of Bradshaw into his academy's curriculum, and set his pupils to work out problems in cross-routes and connections. Both Edmondsons have been credited with having devised an arrangement which rocked the cradle and churned the butter at the same time, but we believe the honour is really Thomas's, who had invented many things before he dated his ticket and booked himself to fame.

On the Midland the little bits of pasteboard are made at Paisley and are supplied in boxes of 50,000 each.

Most of them are in four plain colours for singles, first and third, and up and down ; next come the four returns, each of two colours ; and then comes a miscellaneous assortment of combinations of stripes and hoops for excursion work. How many varieties there are on the Great Western we know not ; but many years ago, during Banbury Fair, the clerk giving an extra tug at a ticket which had stuck brought down the rack with a crash. Such a scene of beauty as the floor of the office then presented will not soon fade from the memory. In a confused heap lay firsts, seconds, thirds, parliamentaries, expresses, excursions, singles and returns, to probably every station on the system. To sort them was impossible with the crowd clamouring at the window, and the staff had to set to work to write the tickets from counterfoil books, and ever afterwards bless Thomas Edmondson.

As a rule, every station has a stock to last six months. The ticket rack is a case of tubes, each just large enough to allow the tickets to slip down it. In every tube is a column of tickets, differing from each other only in being consecutively numbered ; at the lower end is an opening just large enough to permit a ticket to be drawn out. Tickets are usually numbered up to 9999, and then a new series begins, and the series letter or number is one of the printed marks. Between large stations a series is soon run through ; but there have been tickets of such little use that even only five have been printed at a time.

Before the booking begins the numbers of all the bottom tickets are taken, and as each ticket is sold the next to it is drawn slightly forward. As the ticket is issued it is dated in the dating press, to prevent fraud and to ensure its being used within a certain time. When the train has gone the projecting tickets show the tubes

that have been worked ; in each of these the number of the projecting ticket, less the number noted before the train was booked, gives the number sold, and in this way the 'train book' is made up, and not only is the cash taken arrived at, but the amount and class of traffic to each station by each particular train.

Every day the totals of the train books are entered in the summary book, and this gives the day's takings, which either go to a larger station or are paid into the bank. Every month the starting and closing numbers of every tube of tickets are entered in a book, and a copy of this goes to the Audit Office. Everything has to balance, no matter how large the transactions may have been. And railway takings run into large sums, as we have seen. At Euston each booking-clerk takes in the year over £60,000, and this by simply issuing these little bits of pasteboard through the office window ; and light as those little bits are, the North-Western uses fifty tons of them in a year.

Tickets are 'examined' to keep passengers from going on the wrong road ; they are 'nipped' and 'punched' to stop their being used twice ; and they are 'collected' at the journey's end as a check on the booking-clerk and others who might lend themselves to a swindle. After collection, they are arranged in consecutive order and returned to the Audit Office. All through-tickets go to the Railway Clearing House. If a passenger takes a ticket, say, from London to Perth, the ticket comes back next day to London, and each of the companies over whose lines he has travelled is credited with the proper proportion of his fare. Such is the simple system of passenger booking, designed to give the minimum of trouble to the travelling public, and generally thought well of. There are, however, a few ignorant persons

who strive to cripple it by travelling without tickets, or losing their tickets, or putting them to uses for which they were not intended. But with the spread of education, and the increase of idiot asylums, such people become fewer; and every year there is a slight increase in the percentage of tickets returned from the collectors in good condition.

It is said that a collector can take 4000 tickets an hour; but how many season-ticket holders is he able to recognize in the same time? In truth, there are a large number of 'seasons' who are thoughtlessly unreasonable in this matter. 'The moon looks on many brooks; the brook sees but one moon.' The collector looks upon many ticket-holders; the ticket-holders see but one collector, and expect him to be as well acquainted with them as they are with him. What a task this recognition must be! There are ten companies having each more than 20,000 season-ticket holders. The North-Western takes nearly £287,000 from its periodical ticket-holders, the Lancashire and Yorkshire takes over £255,000, the South-Western nearly £200,000. Altogether there are a million and a quarter season-ticket holders in Great Britain, and to recognize these there are about 2000 ticket-collectors! If we can in some slight degree mollify the anger of the hasty at being asked to show a ticket even every morning, we shall not have wasted space in pointing out that these figures average but one collector for each 625 faces!

On the North-Western the 'seasons' return about an eighteenth of the passenger takings; on the Brighton they yield almost an eighth, and the Brighton is doing its best to make the proportion even greater. Its first and second ordinary tickets return over a third of a million a year, and its first and second seasons bring in nearly £247,000, or nearly two-thirds of the ordinaries.

For three pounds one can travel first-class for a week from any station to any station on the system. It is not a large line, having but a mileage of 438, but for £60 a passenger can travel for a year first-class, all over it; and between London and Brighton, its chief termini, a first-class annual ticket costs but £30, or one shilling and tenpence a day.

Another great 'season' line is the South-Western, distinguished above all lines for having for years issued third-class seasons to certain stations. Another is the Great Eastern. But these are much larger affairs, the one having twice the mileage and the other more, but on neither is the proportion of seasons to ordinaries so great as on the 'model,' whose gamboge engines are the trimmest south of the Thames. And, by the way, if these engines were not named after the stations, the advertisement of the line would be just as telling, and a fruitful source of confusion would be avoided. The other practice of painting up on the Brighton engines the name of the driver and the distance run is an admirable one, though the mileage looks small when compared, say, with the Great Western locomotives, of which we shall have something to say later on. The passenger engines of Great Britain run 184,000,000 miles a year, the goods engines run 153,000,000 miles. People who are astonished at the rows of figures in the Brighton 'cabs' may perhaps realize the magnitude of railway work if they remember that the mileage of every engine on the Brighton line would have to be added together and multiplied by thirty to get within measurable distance of what the rest of the united companies accomplish in a year.

One more note before we leave this subject of passenger booking. Disregarding Ireland, as we have done throughout, for that island of struggle is still in the dark

ages of railway story, a year's return shows that our season-ticket holders are as numerous as the whole population of New York; that the first-class passengers are twenty-three times as numerous: that the second-class passengers are double as many as the first-class; and that the third-class are ten times as many as all the rest put together, their number being, in millions, 860.

But enough of the passengers for awhile. Let us see how it is with the goods. The railway company after all is but a common carrier, and it is its goods traffic which will remain with it longest and which it does best. We have heard of railway travelling as inferior to walking, riding, coaching, and ballooning; we have not yet heard of its inferiority to any mode of land transport for goods. And it so happens that in no other country in the world is there anything approaching the efficiency of the goods service of Great Britain.

Think for a moment what a goods traffic means. Take no account of the minerals, which are generally in truck-loads in large numbers and easily dealt with. Think of the miscellaneous consignments of all weights, shapes, and sizes which as a rule are received, packed, carried, and delivered with the regularity of the letter-post. Think of the distribution to hundreds of stations of single packages and packages by the score; of shirtings bought in Manchester at noon, and loaded in New Zealand liners before the following breakfast; of wool bought in London one day and sorted out in the Bradford mill at the beginning of business the next; of boots bought in Northampton one afternoon and on their way down Channel the day afterwards; of perishables—vegetables, meat, fish, butter, eggs—and general merchandise from Dundee, Glasgow, Newcastle, Grimsby, Holyhead, everywhere, bought or ordered one day and

delivered hundreds of miles away before nine o'clock next morning.

For its goods business in London alone, one railway, the North-Western, requires 640 horses, in addition to about the same number employed by its agents. Over three hundred of these are kept at Broad Street. In order to see how a goods station is worked, to Broad Street let us go. Here are seventeen acres furnished with lines affording room for 820 trucks, and the average trade is 456 loaded waggons inwards and 508 loaded waggons outwards per day. To load and unload these there are 54 hydraulic cranes and 129 manual cranes, besides the lifts and hydraulic capstans.

The theory of railway booking is for every passenger a ticket, for every parcel a consignment note. As the vans enter the gates they are stopped, and the consignment notes they bring are stamped. Were the notes not officially stamped at the outset, false notes might be substituted on the road, and the goods diverted into the wrong hands. Should there be a package without a note, one is made out for it; should a whole van-load have but one note, a separate note is made out for each consignment.

Along the front of the fourteen arches runs a platform to which the vans draw up. The notes are handed to the checkers who are in charge of the gangs of unloaders; and as the packages are removed they are checked with the note and weighed on the machines. Down every arch is a platform, on each side of which a train is being loaded for a particular district; each 'run' is numbered, and the checker has the packages wheeled away to the proper arch. With it goes the note, which is taken possession of by another checker, and with it the package is run down close to the proper truck. When the package is on board the note is sent to the

Shipping Office, where it is dealt out to an invoice-clerk, who enters it on an invoice to the station to which it is addressed, and these invoices are handed to the guard in charge of the train. Every note is consecutively numbered, and the entry on the invoice has this number, so that the whole history of the package can be traced. The note is kept in the Shipping Office, the invoice is taken away by the guard and handed over at the unloading.

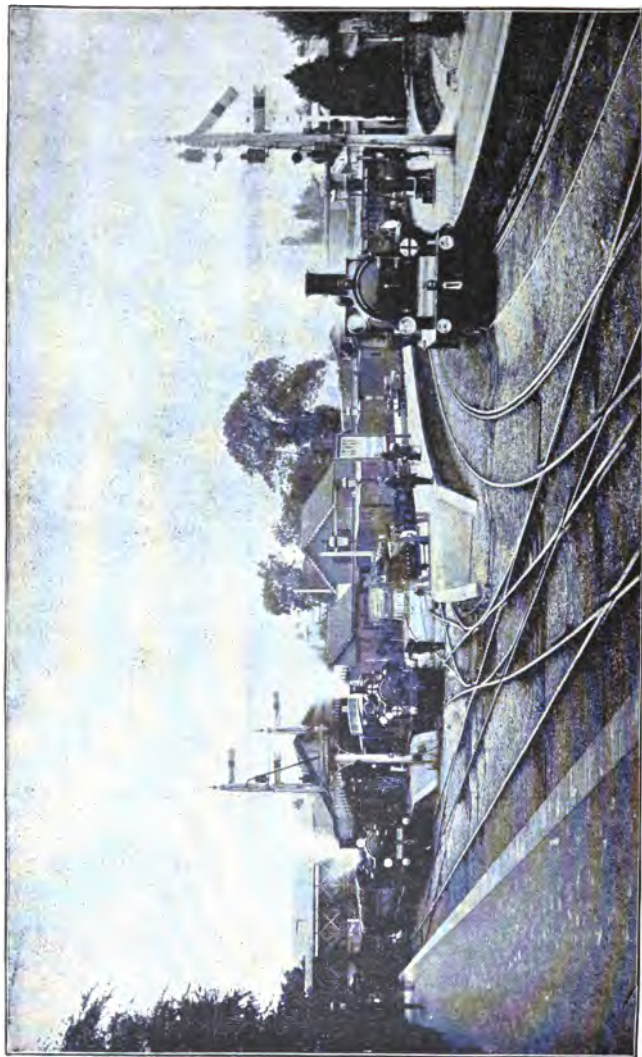
The waggons that have brought goods in the morning take goods back in the evening ; up to noon the work is mostly inwards, after noon it is all outwards.

When the goods come in, the invoices are received at the Delivery Office, where they are copied, numbered, timed, checked as to rates and extensions, and marked with the position on the platform where they are to be placed. By means of letters and numbers on the columns that hold up the station roof, London is mapped out into districts, and thus the marking-clerk's task is facilitated. He passes on the invoice to other clerks, who enter up the van delivery sheets. From these the vans are loaded, and in this way the load of a single truck can be divided among twenty carmen, and packages from twenty trains can find their way into a single van. When the vans are ready the cartage department takes possession and horses them, and away they go with the delivery sheets to the group of streets they serve.

How quickly these incoming goods can be dealt with can be made clear from the story of one train. The Scotch 'Meat' leaves Carlisle at 8.51 p.m., being ten minutes after the Scotch 'Mail,' and at this interval it pursues that train all the way to Willesden, where it runs off to Broad Street and begins to unload at a quarter to four in the morning. The Metropolitan Meat Market contains nearly 250 stalls, all of which receive meat from

the railways, and it is the custom of the market that the railway companies not only deliver, but hang the meat and have it all in order before the arrival of the salesmen. Thus one of the waggons of our train may have thirty sides of Scotch beef for delivery to as many consignees in as many different parts of the market, while other meat may have arrived by other trains for the same consignees ; and this all has to be sorted and gathered and despatched so that no two vans will be simultaneously delivering at any one of the Smithfield stalls. Here is a nice little problem in goods management, which is quietly solved every market, and that so quickly that no matter how early the salesman may arrive, the meat that was 300 miles away when he went to bed is hanging up round him ready for sale !

Out of Broad Street after 7.27 at night there is a goods train every quarter of an hour up to 11.20, the last one taking trucks for nineteen different places. No sooner is it out of the way than the trains begin to run in. As it is with Broad Street, so it is with the other London stations, and so in a less degree with the stations in the manufacturing towns. Broad Street is but an example ; a similar state of affairs exists on the Midland, the Great Northern, the Great Western, the Great Eastern. All night long the goods trains are running at higher speeds than Continental expresses, and in the small hours of the morning they arrive, bringing a steady stream for the most part, but now and then an almost overpowering flood. The unexpected is generally perishable ; it may be herrings from Peterhead or Yarmouth, or meat or fruit from Glasgow or Liverpool, or '578 tons of green peas from Maldon,' or '68 truck-loads of broccoli and 12 tons weight of narcissus' from Penzance. But, whatever it may be, the bulk of it has to be delivered before the clock strikes nine.



LEWES JUNCTION.
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CHAPTER III.

IN THE SIDINGS.

THE visitor to Cardiff may well wonder where all the coal comes from and whither it goes. Ten million tons pass through the place in a year, in quantities small and large, sometimes in such large quantities as from three to four hundred truck-loads in one cargo. In come the loaded trains; up in the air go the trucks; with a roar they are emptied into the hod which swings round over the hatchway, drops, and shoots the coal with a clatter into the ship's hold; and out of the hod and the hold rolls the cloud which is as healthy as a charcoal biscuit. 'Keep off the edge of the quays, as the coal-dust, especially in calm weather, makes the water look like land.' Such is the prominent notice in the docks; it is so suggestive of the state of affairs that we need say no more.

One point of interest there is to us in the destination of the coal. We are so accustomed to see trucks of coal, and to see engines burning coal, that it comes as a surprise to find coal exported to a distant land and there used for railway purposes. Some of the Indian lines burn wood and local coal; some burn wood alone; but a few, like the Bombay and Baroda and the Gaekwar's line, actually import their coal from Cardiff; while the South Indian works its engines with coal from both South Wales and New South Wales. And Indian railways are not small

ones; their total mileage is as great as that of Britain; and they employ over a quarter of million of men.

The coal trucks at Cardiff are a sight to see, but yet they carry not a twentieth of the coal yearly hauled in this island. The mind refuses to realize the quantity. Averaging trucks at ten tons each instead of the usual eight, so as to eliminate the sundries, 253 million tons, the year's haulage of minerals, would require over 25 million trucks, which at 350 to the mile would extend to more than 72,000 miles. If the notice as to the water was enough for Cardiff, is not a row of trucks that would put a girdle three times round the earth enough for a notion of the country's mineral traffic?

It is the easiest of traffics to work. The trucks are loaded full at the colliery and generally made up into complete trains, and these in due order run on to the main line to be dropped in detachments or run through to the terminus. Forty years ago the work of carrying goods was performed by the Pickfords and other carrier firms, who provided their own sidings and built or rented their own stations and stores. The railway company merely provided the road and the power, and hauled the trucks without any responsibility for their freight. It was the carrier who loaded and unloaded the goods, checked and weighed them, and handed over the trucks full or empty in a convenient position for the engine to get at them. Nowadays the companies are the carriers, and have control of most of the sidings and goods warehouses; but many of the trucks are the property of the colliery owners, merchants, and traders, the arrangement being a survival from the old system. Usually these trucks are built and run subject to the inspection and approval of the railway companies; but the Midland, in their care against accidents, have gone further and become the owners of the majority of the trucks they

draw. How the figures tell up ! The Midland working stock is returned at 116,082 trucks; the North-Western has 61,000 trucks, to say nothing of the immense number of private trucks working on the line, which is much larger than on the Midland. The Caledonian followed the Midland lead and began to buy up the private trucks on the line, but somehow the policy has not been pursued, rumour having it that certain of the private owners sold their second-hand trucks to the company, and with the proceeds bought other trucks to sell in like manner, in continuation of a circle of profitable trade.

The coal traffic is now as aggressive as it is humoured; but it began in the quietest way imaginable. It literally stole on to the line. When it was proposed to accept it, one of the London and Birmingham directors exclaimed that there was only one lower depth to which his trade could sink. And in witness of his sense of shame there stood for years the screen at Weedon behind which coal was furtively transferred from the canal barges to the highly superior company's waggons ! And to cover the coal from prying eyes the waterproof sheets came in, which are now used to keep the weather from the miscellaneous goods.

Taking even these sheets, what an idea they give of the magnitude of railway work ! A few years ago at the Midland sheet stores near Trent, there were drying rooms heated by steam in which 600 sheets could be dried at a time, and the numbers are not likely to have decreased. The strips of canvas twenty feet long were sewn together by giant machines, and then the sheet rubbed over with boiled oil and vegetable black, coat after coat applied with brooms, till it was cured and hung on a scaffold pole ready for lettering. Every company has its distinctive marks: the North-Western has its two red lines, the

Northern its white and blue diagonals, the Midland its yellow edges, the Brighton its slender white cross, the South-Eastern its red cross, and so on. Each sheet is worth some two pounds, and requires frequent repairs—in fact, no sheet can be trusted to be sound even after a single journey.

It is curious to note how customs differ even on the railroads. In Belgium, for instance, the use of a tarpaulin for covering goods is specially charged for, it being one of the numerous little extras by which the nominal rates are improved. To 'count' your goods the Belgian charges you a penny a ton, to weigh them he claims fivepence per ton, to 'book' them he charges you twopence, to 'label' them he charges you another twopence, to send the 'advice' he charges you a penny, for the 'use of the crane' he charges threepence per ton, for the 'use of the tarpaulin' he charges you one shilling and sevenpence, and for 'disinfecting the truck' he charges you a shilling. No wonder that the Belgian journalist considers that the railway charges should be 'assimilated to the English model.'

On this side of the Channel a good many people have been thinking that the reform should be the other way about, though the average receipts for each mile run might warn them to be careful in coming to conclusions; for in France and Germany the receipts per train mile are more than half as much again as they are amongst us; and even in Belgium they are greater, and there the expenses on the receipts are 59 per cent., whereas amongst us they are 52.

In this country the wages form 60 per cent. of the working expenses; in Belgium they form 58 per cent., in Holland 49, in France 47. Here an engine-driver does not earn less than 5s. a day, on no Continental line does

he receive more than 5*s.* a day; so it is with the firemen, the Continental wages leave off where ours begin. The wages of our guards range from a guinea to 2*l.* a week, those of the Dutch guards range from 13*s.* to a guinea. In Germany the range is from 15*s.* to 26*s.*; in Belgium the guard is made more of, and his wages range from 18*s.* 6*d.* to 34*s.*; in France he may even rise to 38*s.* 6*d.* Our signalmen are paid from 18*s.* to 30*s.* a week; the French signalmen are paid better, the range being from 18*s.* 6*d.* to 32*s.*; but the German signalmen never rise above 23*s.* a week, the Dutch never above 22*s.*, and the Belgian begins at 12*s.* and leaves off at 17*s.* 6*d.* Our porters are paid from 15*s.* to 24*s.* a week; those on the Continent begin at 13*s.* and rise to 20*s.* The wages of our shunters rise to 26*s.*; in Holland they stop at 22*s.*, in France at 17*s.* A Dutch platelayer gets from 12*s.* to 14*s.* a week, a German from 12*s.* 8*d.* to 14*s.* 6*d.*, an Englishman from 15*s.* to 23*s.*

In short, the wages are less and the charges are more. A Frenchman, Belgian, Dutchman, or German, is simply aghast at some of our food rates. Even from Wick by passenger train no fish costs more for carriage to London than three-farthings a pound, while from Grimsby the bulk comes at five pounds for a penny, being just a fifth of what it costs to carry a living man. As with the fish so with the meat. From Aberdeen to London the highest rate is three pounds for a penny; and vegetables are carried the same journey for six pounds a penny; bacon and cheese travel a hundred miles for eight pounds a penny; and milk comes the seventy-seven miles from Swindon at the rate of a penny a gallon.

But we are trespassing on thorny ground; let railway rates wait awhile, and let us return to our tarpaulin. Great is the variety of the goods it covers. They may

be of iron measuring seven cubic feet to the ton, or they may be furniture bulking out to the astonishing cubage of 3,500 feet to the ton. But however miscellaneous may be the load, the tarpaulin looks dressy enough when new.

In the twilight of a summer's evening we recently saw six new trucks with sheets complete forming quite the prominent feature of a passing train. It was one of those trains which grow as they travel. It started with four trucks; it picked up four more at a junction twenty miles away; six more tailed on outside a great city; and thus matters went on until thirty-eight were passing us on their way to the south. As the train went so would it return, but distributing trucks instead of collecting them as it came northward.

We were by a gate at a certain sorting sidings at least two hundred miles from Cardiff, and watching what seemed to be the solving of an interminable puzzle. The train glided along the curved outer edge of a wide grid-iron of parallel roads, and headed in pursuit of the express which had left its steam still floating in the valley. Here and there on the gridirons solitary waggons were running as if racing each other. From a train to the right of us truck after truck was dropped off and sent travelling down sometimes one and sometimes another of the many parallel roads, to meet at the bottom in very different order.

'Sorting and marshalling' is a mystery to many, but curious as are some of its problems there is little difficulty in understanding the principle. In the large stations the trucks are loaded in 'train order,' that is to say, a train or portion of a train is loaded at each platform, and when, as at Broad Street, they come up by the lift on to the high level, all that has to be done is to couple on the engine and drag them away. But all

stations are not large ones, and 'train order' is not universal; and if it were, the order could not be retained over a wide area of distribution. Not only, then, have packages to be sorted like letters, but trucks have to be sorted like packages; and an interesting operation it is.

The popular notion of sorting is a miscellaneous hauling up one line and down another until the arrangement is satisfactory. That was 'shunting' in its infancy. Nowadays time is too valuable to be wasted, and the time-saving gridiron system is in general use. Let us try to make the system clear without a diagram. Essentially the problem is:—Given an alphabet on wheels, how are we to arrange it in any particular series? Let us take it in confusion. Here are our letters—

B Q C D E R J L M A I O U Y T F H G N K S P V W X Z

all of which have to be dealt with one by one, as none of them can stand aside to let another pass. They represent a row of trucks on a single road with the engine at the B end; to perform the task of arranging them in alphabetical order at one operation is manifestly impossible; but by sorting them out into short lengths we can manage it in two, if we so fill our columns as to keep the letters in order of precedence. For instance, let us take B down the nearest road, and then as Q is some distance on in the alphabet let us send it down the next road. Send C down the first road after B, let D follow C, and E follow D; R will of course go down the Q road, but J being an earlier letter than Q will have a new road to itself; L can follow it, so can M; A must begin a road, and I can follow it; O must be sent down the M road, and U can follow it; and Y can follow that; T can follow R, and F can follow E, and H can follow it. In our first column we can now take nothing before H, in our next nothing before T, and in our next nothing

before v, in our last nothing before i; we must consequently begin a new column with g, and follow the g with n. k we can send after i and s after n; p will go after k, and v w x can be placed in the r line; and z we can put after s. The state of affairs will now be—

H	X	Y	P	Z
F	W	U	K	S
E	V	O	I	N
D	T	M	A	G
C	R	L		
B	Q	J		

Here are five columns or roads in none of which are the letters or trucks out of order. There are many gaps, but these we will fill up at the next operation. We will take away A and place it by itself. Then we will return for B C D E and F; from the fifth column we take G; from the first H; from the fourth I; from the third J. Our columns are now—

X	Y	P	Z
W	U	K	S
V	O		N
T	M		
R	L		
Q			

and our line A B C D E F G H I J. Continuing the operation with k we gradually exhaust the columns and fill the line with the trucks in the required order. Let it be clearly understood that this is a purely imaginary train made up only as an example of the general principle, and dealt with just far enough to show the plan of a sorting siding with a single gridiron.

Every great railway has its sorting sidings. The

Midland sorts most of its goods at Chaddesden, near Derby, where the gridiron—answering to the columns in our example—consists of thirty-five roads, on which a train of forty trucks can be broken up and re-formed in four minutes, and from which there is despatched a train every seven and a half minutes during the twenty-four hours. The Midland ‘minerals’ are dealt with chiefly at Toton in the Erewash Valley, where about four million tons of coal pass through the gridiron in a year. The Lancashire and Yorkshire sort on a large scale at Aintree; the North-Eastern at Shildon and Blaydon. But the most famous sorting sidings in the North country are those on the North-Western at Edge Hill, near Liverpool, where there is a yard of 200 acres, with 57 miles of road, and siding room for 6,500 trucks.

At Edge Hill the work is done, not by engines or horses, but by gravitation, the trucks being sorted out as they descend a hill-side. On the higher ground are six reception roads with accommodation for 294 trucks; connected with these by a ‘neck’ is a gridiron of twenty-four roads on which over a thousand trucks can stand, and this, by other necks, communicates with four smaller gridirons leading on to the departure roads. The gradient varies from 1 in 60 to 1 in 115, the greater incline being when the trucks have to start singly and enter curves. Strange it is how, even in railway trucks, the rule of ‘no two alike’ holds good. Here, under practically identical conditions, every truck has some peculiarity in its running; and the examples are numerous enough to generalize upon, for the year’s work through Edge Hill gridirons totals out to close on 700,000.

The shunting yard is said to be ‘the shambles of the railway man.’ At Edge Hill only one man has been seriously injured since this gravitation system was

adopted. There is always danger in shunting, even if the stick be used which does away with the need of the man's placing himself between the trucks. Danger, however, is a matter of personal equation after all; we have seen that individual trucks differ in their behaviour, and individual men differ more; what is danger to one man is safety to another.

From the percentages of accident one would, however, imagine that shunting was not a particularly risky operation. There are half a million waggons working about the railroad every day, and for the whole of a year the deaths of railway servants occasioned in connection with trains and by 'the movement of vehicles' was 411, or rather more than one a day. The injuries are about seven times as numerous, so that, altogether, about 3,200 men come to grief in a year, being about one per cent. of the number employed; but there is no doubt that this percentage, small as it is, is greater than it ought to be, and a feeling is growing up that a system of automatic coupling should be generally adopted, which would have the double advantage of saving both life and labour.

Ten years ago the railways of this country gave employment to 367,800 men; to-day, the railway staff is of course larger, but the 1884 record is worth remembering owing to its having been classified into the different occupations. It appears that Civil Engineers then formed '03 per cent., being in exactly the same proportion as Storekeepers and Goods Managers; next to them in number came Accountants and Cashiers, forming '04 per cent., the same percentage as Superintendents. Managers and Secretaries formed '05 per cent. Draughtsmen formed '07 per cent.; Agents formed '23 per cent.; Gatekeepers formed '44 per cent.; Policemen '48 per

cent.; Ticket-Collectors formed '56 per cent.; the Refreshment Department claimed '68 per cent.; Foremen formed '79 per cent.; and Inspectors and Time-keepers '96 per cent. The Telegraphic department occupied 1 per cent.; Stationmasters formed 1'68 per cent.; Engine-drivers formed 3'5 per cent., being just a trifle more numerous than the Firemen; Guards formed 3'62 per cent.; Signalmen and Switchmen together formed 5'17 per cent.; Platelayers formed 8'11 per cent.; Clerks 9'15 per cent.; Porters formed 12'13 per cent.; Artisans 15'21; Labourers 19'14; the rest of the staff, including the steamboat and canal services worked by the companies, being accountable for about 13 per cent. The most remarkable thing about the railway service is the number of leaders who have risen from the ranks, there being hardly a head of a department who has not been through the mill. Some have even started in the goods yard at fifteen shillings a week.

The railway staff can be divided into four departments, those of the Superintendent, the Goods, the Locomotives, and the Engineer. The Superintendent's department includes the guards, ticket clerks, porters, signalmen, and most of the men who are before the scenes in railway work. To it belong about 21 per cent. of the staff; to the Locomotive department, which is chiefly represented in public by the drivers and firemen, there belong 37 per cent. of the staff; to the Engineer's department, rarely in evidence except in the person of the platelayers, belong 23 per cent.; to the Goods department, which is much more under observation, there belong 19 per cent. Taking the whole staff, it is not too much to say that two-thirds of it exist behind the scenes, and are never even dreamt of by the railway traveller.

The goods-yard porter is not the least important of

railway workmen. The carriage-washers, the men with the broom and bucket, and the cleaners, the men with the brushes, have a far humbler task as the railway housemaids. On a well-managed line the passenger carriages in use are washed outside and cleaned inside every day, but there are lines on which it is evident the will has to be taken for the deed. How many varieties of vehicle pass under the washer's broom in a day we know not; but if a specimen of each from the earliest South-Eastern to the latest North-Western were sorted up into a train, the train would be a long one.

And not only have the carriages to be cleaned, but, like the trucks and brakes, their machinery has to be examined; and though all may seem to be right, yet at intervals they have to be returned to the repairing shops to be thoroughly overhauled, and even if nothing else be wrong to have their springs tested.

One of the most interesting shops at Swindon is that in which the springs are tried. No matter how good the metal may be, there is always a danger that alternations of temperature will cause it to assume the crystalline state; and hence the need of occasionally heating it to keep it in condition. To see the heavy springs brought in and have the band pushed off them as if it were of cheese; and, on the other hand, to see the completed spring put in a press and tested to a dozen times, perhaps, of what it may be expected to bear, is to witness an experiment in quiet strength that one is not likely to forget.

Here is the spring on a bed with its ends fast against two blocks, and the ram advancing at its centre. 'Will it bend it straight?' we ask. 'Yes,' replies the foreman; 'look!' And the spring is held with its plates perfectly straight and parallel. 'I will show you what we can do,' continues the foreman. 'Bring that long spring here!'

One of the most powerful springs is laid on the bed and fastened in the blocks. 'Now!' Out comes the ram, the spring is bent until it is straight, and still the ram advances and bends it as much outwards as it bends inwards in its normal state. Again and again see-saw goes the ram; and the spring is removed from the block having lost not one whit of its original curve. Close by there is a beam balance some six or eight feet long, on which the weight in tons the spring will bear is being found. Every corresponding spring in a carriage or an engine must give at the same weight; were it otherwise the running would be unequal.

Swindon has one shed which cannot be much smaller than Olympia in the ground it covers. It is a hospital for goods trucks, with the papers on the patients instead of on the wall at the heads of their beds. Close to this big fellow there is one of more ordinary dimensions, to which the passenger vehicles come for repair, and here the most noticeable features are the lifts for taking the bodies off the bogies, so as to deal with them separately. The Great Western had a class of carriage unknown on any other line. It ran narrow gauge bodies on broad gauge frames, in order to be ready for the inevitable day when the broad gauge ceased to exist. That that would not be long in coming was apparent enough from the state of the track.

But the battle of the gauges is over now, and nearly all that is left of it is the sharing of New Street station on easy terms by the Midland. The word narrow gauge is obsolete as meaning 4 ft. 8½ in., and we now speak of 'national gauge'; and the historian tells us how the national gauge arose from the measurement of country carts found wide enough to pass each other in a lane.

The crisis of the battle was in the West. Was the broad gauge to run from Bristol to Birmingham, or was

the national gauge to run from Birmingham to Bristol? Which was to have the traffic from the Midlands to the West? Was it to be Great Western or Midland? The Great Western offered to buy in share capital, the Midland offered a six per cent. dividend on the old capital; and, needless to say, the Midland won. Whereupon, the North-Western, which had been backing the Midland in keeping the Great Western from coming up the Severn valley, compromised its guarantee regarding the yearly loss on the six per cent. arrangement for perpetual admission of the Midland into the new Birmingham station at the nominal rent of £100 per annum. For three years the Midland lost money on its six per cent. plunge, but since 1848 it has been on the right side, and the New Street bargain has not been a bad one.

The Midland has done much for railway progress. By winning this gauge battle it gave the country a national gauge, and by saving transhipment at break of gauge reduced the cost of transport. By abolishing 'expresses' and 'special expresses,' it led the way to the uniform fares now adopted by nearly every other line. By the introduction of 'third class by all trains' it began a new era in railway management, which it has further done much to develop by the abolition of second class, the importation of the Pullman Car, and the great improvement of third-class carriages.

The Midland startled the railway world with 'henceforth third class by all trains' on April 1, 1872. Gradually the policy has been generally adopted, and at last even the Great Western hauled down its flag of exclusiveness and joined the popular movement by sending all three classes by the Dutchman and the Zulu.

The advance of the Great Western has been one of the notable features of railway history. Twenty-five years ago, when the late Sir Daniel Gooch became its

chairman, its mileage was 1,256 and its dividend was 2 per cent.; it has now almost doubled its mileage and more than trebled its dividend, and its receipts from its passenger traffic alone are as great as they were then for passengers and goods combined. And as it has advanced in prosperity it abandoned its original gauge.

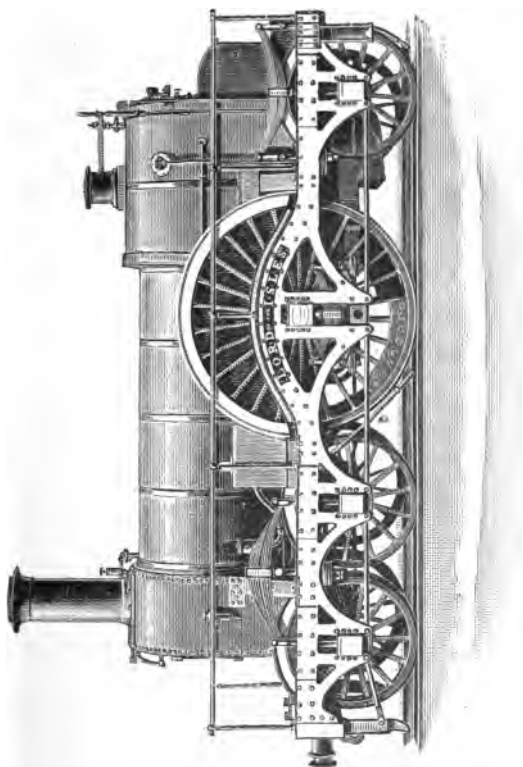
The disappearance of the broad gauge was the most interesting railway event of 1892. The outer of the three lines which marks the Great Western track had long been getting rusty, and now it is to be left as a mere remainder to be cleared out at a moment's notice. The wide roomy carriages in which we seemed at times to float along the easy line to Swindon are now no more, and those wonderful engines, which promised to last for ever, and whose names were almost as familiar as those of our newspapers, have taken their place among the curiosities of locomotion.

As casting more light on the work of a railway engine, a few particulars have come to hand regarding the distances travelled by these giants of the past; and a wonderful record it is. There were thirty of them, and reckoning only their running up to the time they were rebuilt or condemned, they between them accomplished close on $18\frac{1}{2}$ millions of miles, or an average of over 600,000 miles apiece; and 600,000 miles means—twenty-five times the distance round the world!

One of these engines, the Lord of the Isles, withdrawn from the track in July, 1881, ran 789,300 miles before she wore out her original boiler. Seven only of her sisters joined her in retirement, the rest, after rebuilding, remained at work, and now leave the road owing to there being no road left for them to run on.

The first of the thirty was the Great Western, built forty-six years ago; her run up to rebuilding amounted to 370,687 miles—the shortest of the lot, except that of

the Kertch we shall come to in due course. Next year, 1847, six engines of her class came on the road. These were the Iron Duke, the Lightning, the Great Britain, the Emperor, the Sultan, and the Pasha. Of these the best, or luckiest, was the Lightning, which before she was rebuilt in 1878 actually ran 816,601 miles, the longest 'first life' in Great Western annals. The Great Britain did the worst in her original build, which lasted up to 1880, by which year she had run 403,644 miles. The Sultan did 727,000 miles—we need not give the odd hundreds—the Emperor 690,000; the Iron Duke, rebuilt in 1871, 607,000; and the Pasha, the only one of the half-dozen which did not last to see the track out, 613,000. In 1848 seven new sisters came out into the world. Four of these lasted on; three of them, the Wizard, the Rougemont, and the Hironnelle, were in time withdrawn. The Rougemont scored 772,000, the Wizard 711,000, the Hironnelle 605,000. The Courier, rebuilt in 1877, scored up to then 746,000; the Tartar up to 1876 scored 731,000; the Dragon up to 1872, 670,000; the Warwick up to 1874, 639,000. There were three new-comers in 1849, the Tornado, Swallow, and Timour. The first of these ran, without rebuilding, 688,000, and both the others 569,000. In 1850 came the Prometheus, the Perseus, the Estafette, and the Rover, of which the first and last only lasted to the end. The first was rebuilt in 1870 after accomplishing 538,000; the Estafette only managed 504,000; the Perseus managed 722,000; the Rover had the shortest first life of the batch, scoring only 461,000. In the Exhibition year came the Amazon and the Lord of the Isles, the first of which was rebuilt twenty-six years afterwards after accomplishing 729,000; the second was never rebuilt, but had one long life and a merry one with the results already noticed. In 1852 there were no new engines of her



THE LORD OF THE ISLES.



class, neither were there in 1853, but in 1854, in the thick of the Crimean war time, there came the Alma and the Balaklava, the second of which was rebuilt in 1871, after running 406,000 miles, the first receiving her new build the year afterwards, when 444,000 stood to her credit. In 1855 came the last of their class, the five other Russians—Inkerman, Kertch, Crimea, Eupatoria, and Sebastopol. The Kertch ran only 326,000, about half what was done by the rest. The Inkerman was rebuilt in 1877 with 650,000 miles to her credit; the Crimea and Eupatoria underwent rebuilding in 1878, after the first had scored 605,000, and the other 618,000; while the Sebastopol held on until 1880, when she had done the splendid run of 707,000.

Let it be clearly understood that this is merely the mileage up to rebuilding; the total mileage is another matter which we may be able to say something about when the broad gauge accounts are finally closed. It may be asked, 'What is the best on record accomplished by a locomotive?' Really nobody knows, but something very like it is claimed for the Charles Dickens, belonging to the North-Western, which in 9 years 219 days travelled over a million miles. With a certain amount of humour the performances of this engine were recently described in the first person.

'Sir,' said the engine, 'some hitherto unpublished correspondence of Dickens having been recently given to the world, and more being in request, I have thought the public, especially of Manchester, and those engaged in the mechanical engineering profession, would regard as opportune and otherwise appreciate a further contribution of the kind direct from myself.

'It will be remembered from my already published correspondence how I was turned out of the Crewe works on February 6, 1882, sent to Longsight to run as often as

I could between Manchester and London, as a minimum day's work, in charge of David Pennington and Leigh Bowden, taking the 7.45 a.m. train out of Manchester, and returning with the 4.0 o'clock out of London, and was so regularly on the road, in fair weather and foul, in snow and rain, that by September 7, 1886, when my performance had just exceeded half a million of miles, the friends I had so often carried safely had christened the trains I worked the Charles Dickens, and had ceased mentioning the times of departure when making their travelling arrangements.

'On March 17, 1886, I lost my faithful groom, David Pennington, through his eyesight being unfortunately injured, but Josiah Mills, who succeeded him, together with his mate, Leigh Bowden, who has been with me from the commencement of my career, have been so attentive to my various daily wants that to-day, when about half-way between Mow Cop and Harecastle, on my 2,651st trip to London and back, I accomplished the, so far as I know, unparalleled feat, on either this or the other side of the Atlantic, of running 1,000,000 miles in 9 years and 219 days. In addition to the 2,650 trips to London and back, I had run 92 other trips, consuming 12,515 tons of coal, and evaporating 93,237 tons of water. Although it may seem more extraordinary than my athletic achievement, through the effective arrangements of my designer, and the convenient interchangeable system peculiar to the Crewe creations, I have had two new digestive organs supplied to me since my birth, but such has been the quality of the food and medicine received throughout, that neither these nor the original are yet worn out; in fact, the first was in such excellent condition that after I laid them aside my sister Snowdon travelled 191,236 miles with them, Balmoral afterwards appropriating them, and is still running with

them. Courier became enamoured with my second, and is making a good record therewith. My third will, I hope, raise the steam for me for many a day to come ; and I myself trust to witness, with many old acquaintances, the dawn of the twentieth century, although whether my constitution will hold good for another million of miles remains to be seen. At present I feel no symptoms of decay ; all my energies are unimpaired, and by the kind indulgence of my master, I and my grooms are just off to enjoy a week's holiday during the gloriously fine weather now prevailing.'

The Charles Dickens, which is still working, is, it may be as well to note, numbered 955, and is of the four-coupled type, with 6 ft. 6 in. driving wheels, 'four-coupled' meaning two coupled driving wheels on each side ; and those anxious to look out for her will notice that she has six wheels in all, four large and two small ones in front, her tender being of the usual six-wheel kind.

Of course there was nothing very sudden about this ending of the broad gauge. For a long time the Great Western had been building its engines and carriages on a convertible principle with narrow gauge bodies on broad gauge frames, so that only the under parts needed alteration to fit them for the new condition of things. Gradually the narrow gauge had been substituted for the broad all over the system, first in the Midlands and to the North, then in the West and in Wales, then in Dorset, Wiltshire, and Somerset, and so leading on into Cornwall.

It was in Cornwall that there existed until recently one of the most curious of British railroads. When 'the battle of the gauges' was at its height there was a tremendous struggle between the Great Western and South-Western for the isolated Bodmin and Wadebridge. A

reference to a map will show this insignificant railroad on the western coast. It never was a flourishing affair, indeed it had paid no dividend at all when the Great Western and South-Western persuaded themselves that it was absolutely necessary to possess it with a view to future incorporation. The Great Western got as far as guaranteeing a dividend ; the South-Western capped that proposal by offering cash down ; and for cash down the South-Western bought it, to leave it out in the cold till 1891, as if it were on an island. Many anxious to see what a railway used to be journeyed west to get a glimpse of the Wenford branch of this line before it was too late. Its chairs were about as big as a man's hand ; its sleepers were stone blocks, to which its chairs were hammered by tenpenny nails. There it was left, a relic of the stone age of railway development, a page of the old gauge battle which ended in 1892 with the vanishing of the beaten side.



THE DEPARTURE
PLAY FORM.

'BY YOUR LEAVE, GENTLEMEN.'

CHAPTER IV.

ON THE PLATFORM.

 TRAIN of 110 vehicles, with four engines in front and one pushing behind, is lengthy enough for a stretch of the imagination ; and yet it was in such a train that the people returned from Edinburgh after seeing the Queen in 1842. Nowadays we manage our excursion traffic differently. Instead of cramming all the passengers into one train, no matter how many they be, we divide the crowd into sections, and despatch these in separate trains one after another at 'block' intervals.

If any one will see how a great excursion traffic is handled with success, let him give the Great Northern a trial and pay two visits to Doncaster, one in August and one on the St. Leger day. In August he will find the sidings full of goods trains and coal trains ; on the roads into the works there will be the usual parade of injured rolling stock awaiting its turn for repair ; and in the shops, amid the clang of the hammer and the scream of the saw, he will find a small army busy in a wilderness of bands and wheels.

In the St. Leger week all this is changed ; the workmen make holiday, the works are closed, the goods and minerals are not allowed to stop on the sidings, and the engines and carriages come for repair are either run off

to be shunted further down the line or locked in the silent shops. The block sections around are cut into half-lengths by extra signal cabins. Every siding is numbered, and the number in huge figures is like a target. Every train that is due in has a corresponding number, and hung on to its engine funnel is a board with a big placard showing in large type the stations to which it will return.

Here, then, are numbered sidings, numbered trains to shunt into those sidings, and bills clearly showing what these trains are to do. But something more is required. As the trains run in on the day of the race, every passenger is given a handbill telling him the number of his train, the number and position of the siding in which he will find it at night, and the time it will start.

Whatever the sight on the Town Moor may be, there is no question that Doncaster station-yard is worth seeing while the great race is being run. The whole area is one mass of these conspicuously labelled trains, come from all points of the compass. Say there are a hundred of them, and there are only one or two less; there they stand all at attention, with steam up and staff waiting ready for the rush. At five o'clock it comes; the station is black with crowds, handbills in hand. The trains are like hives thick with stormers, and fill as quickly as if the people had been poured into them. At a quarter to six there is a terrific whistle from an engine, and No. 1 train is off; in a little over a minute off goes No. 2. In five minutes four trains have gone; in the next five four more. In an hour fifty have gone; in two hours they have all gone, and the sidings are silent and empty.

The fine roomy station at Liverpool Street on a Bank Holiday, or, still better, the Epping Forest stations, afford another example of dealing with a plethora of passengers,

but in this case the organization is not so much in evidence or so satisfactory. The longer excursions of the Great Eastern to the North Sea coast afford far more favourable examples of what that rising company can do. Some of these are cheap enough to recall the days of the great competition, when the passenger fare from Leeds to London was five shillings, and occasionally half-a-crown. The man in the moon was wise in inquiring the way to Norwich; should he ever reach that favoured city in an afternoon, he will be able to go from there to Cromer and back, fifty miles, for the small sum of one shilling.

The London line that has most specials is the South-Western. There is not a week passes without Waterloo having to deal with a race or a review, or some excuse for a flood of excursions with which to complicate the ordinary traffic. Portsmouth, Aldershot, Bisley, Ascot, Epsom, and Parks irrepressible afford a continual round of gaiety to the South-Western. From its special trains a large amount of its income is derived. When the fact of the University Boat Race taking place at too early an hour in the morning means a loss of 20,000 passengers, no wonder the special traffic is thought worth cultivation, and when the Boat Race and Sandown Park come together, as they occasionally do, then Waterloo is busy indeed. During the afternoon of the Jubilee Review, the South-Western ran 72 specials between London and Aldershot; and when the Derby was in its prime Waterloo has worked 125 specials to and from Epsom; but the Epsom work is now shared by the Brighton Company, who spoil the South-Western game with their station on the Downs. Since that station was opened the Waterloo traffic has dropped considerably, though the total amount passing through Clapham Junction is much as it used to be.

Clapham Junction—which is not in Clapham at all, but a mile away from it—is one of the busiest of the suburban junctions round London. Between five o'clock in the morning and midnight, a passenger train, up or down, stops at Clapham Junction every two minutes—just as many passenger trains, in fact, as there are goods trains and passenger trains going through Crewe in the twenty-four hours. Of these 600 trains, the South-Western is responsible for over 340 to and from Waterloo; the Brighton, to and from Victoria, provide less than half as many; and the Kensington and other trains that start from the Junction make up the remainder. These 600 trains, be it understood, are ordinary passenger trains only, and no account is taken of the specials and expresses that do not stop, or of the goods and empties, which, taking the year through, would probably total up to half as many again. One of the curiosities of the traffic is that while the South-Western stops fewer trains on the way to Waterloo than on the way from Waterloo, the Brighton reverses the policy and stops more trains on the way in than on the way out.

Waterloo was until recently the largest passenger station in this country: that is to say, it covered a greater area. And it is still the busiest station, for in and out of it there pass about 700 trains a day, and not even the busy Great Eastern comes up to this, although Liverpool Street, which by its enlargement is now our largest station, deals with the larger crowd. The reason is obvious: a South-Western train averages 150 passengers, a Great Eastern train averages over 400.

When the South-Western was young it had no intention of stopping at Waterloo. The plan was to get at least as far as Barclay and Perkins' brewery, if it could not cross the Thames by Southwark Bridge. In fact, the South-Eastern road from Charing Cross to Cannon Street

was simply the revival of the old South-Western project. The terminus at Waterloo was a making the best of the inevitable, and a growth under difficulties from small beginnings; and no South-Western official will feel annoyed at being told that one would have thought as much from appearances. Architectural features it has none; it is a mere aggregate of platforms—there are now actually twenty-five bays—spreading like a fan, and cut up into groups by the most unpretending of offices.

Contrasting with it in every way is St. Pancras, a station with a really fine frontage, and worked simply and straightforwardly under one roof, with nothing to break the view, though how St. Pancras unaltered could deal with the same number of trains at a time as Waterloo is not quite clear. It is, however, a model station, and a wonderful one. The trains really run in the roof; the tie beams that one usually sees aloft stretch across under the platforms, and the girders of the great arch, spanning as many feet as there are pence in a pound, come right down into the ground. The brick walls that are visible are but screens; and the offices, though on the level of the road, are practically in the parapet. The true building that carries the roof is below the level of the metals. In it the storage space, chiefly used for beer, is gigantic. Below its foundations runs the City branch, which has to cross the canal before it can rise into Camden Town; and in addition to this curving tunnel under the stores, there is a spare tunnel under the front of the hotel, for the Metropolitan to use, with a double line of rails, when need arises; and below the tunnels flows the once famous river Fleet safely wrapped in a drain-pipe.

There are thus three floors of rails: the one which the passengers use, the middle one by which the stores are

worked, and the lowest for the City traffic. And the unit of measurement from which the proportions of this vast building had to be designed was no other than that familiar object—the common beer-barrel.

When the station was projected 'it was determined,' says Mr. Williams, the Midland historian, 'that iron columns and girders, instead of brick piers and arches, should be used; and as the area was to be devoted to the accommodation of Burton beer traffic, the distances between the supports were arranged at such intervals as to allow of the largest number of barrels of beer being placed between them. These distances were found to be 29 ft. 4 in. As the great outline of the superstructure had necessarily to be adjusted to the position of the supports below, the unit of the entire fabric came to be founded on the length of a barrel of beer.'

To come to London and make this station and the immense goods dépôt alongside cost the Midland £9,000,000. Time was when the Midland thought of amalgamating with the North-Western and running its trains into an enlarged Euston. Those were the days of the Great Northern war, when the Northern ran a train into the Midland preserve at Nottingham, and just as it was about to return loaded with passengers, the Midlanders made a capture of the engine. Here was a notable episode in everyday life on the railroad: a Northern engine, peaceably backing, finds itself cut off from its train by a Midland engine rushing in from the siding. Halting to consider, the Northern driver sees a second Midland engine backing up the first; striving to escape, he finds a Midland engine in front of him, and another behind that; slowly the enemies advance, deliberately take the Northern engine prisoner, and run off with it between them into shed!

Then the day of the olive branch dawned, and the

foes became friends for a time, and the Midland traffic came to King's Cross. But the Northern could not carry the double load; the state of affairs became exasperating. 'This year 1,000 Midland passenger trains and 2,400 Midland goods trains were delayed in the thirty-two miles between Hitchin and London.' There was no help for it; the octopus of Derby must get a tentacle into London, and to do it was well worth all the money spent.

Attempts are sometimes made to compare American railways with ours. The only comparison must be contrast, so different are the conditions. In this country a railway is bitterly opposed and discouraged, there it is warmly welcomed; here the line has to pass a Government inspection, and be so solidly and evenly built as to bear about the same relation to an American line as a first-class carriage does to a trolley, the object of the Americans being to lay the line at the fastest possible rate, and chance the accidents which occupy so prominent a place in transatlantic telegrams. The number of American railroad accidents is a wonder. Taking the returns of only one month, the last month available, we find 75 collisions, 107 derailments, and 12 miscellaneous disasters—boiler explosions and what not; a total of 194 'regrettable incidents,' resulting in a loss of 40 killed and 193 injured. This is an ordinary month, with no sensational catastrophe to distinguish it, and it means that three times as many railway accidents occur in the United States in a month as in Great Britain in a year. Another point worth remembrance is that in this crowded country the company has to pay for every yard of land, while there it not only gets its land for nothing, but thousands of acres into the bargain, so that the statist of a hundred years hence, when that land is occupied, will be able to show

that to start with American railroads cost considerably less than nothing, while those of old-fashioned Britain cost. £50,000 a mile.

Once, as we have said, the Midland was coming into Euston ; so was the Great Western. In fact, it obtained its Act of Parliament on the understanding that it was to effect its junction with the London and Birmingham in a field between the Canal and the Harrow Road at the western side of Kensal Green Cemetery ; and it was only when the scheme of a joint station was abandoned that Paddington was thought of. The two small departure platforms and the outward parcel offices at Euston now stand on the site of what was intended to be the Great Western terminus.

There is a healthy, well-to-do look about Paddington which no other station possesses. It is the most English of railway stations. Whatever be its order of architecture—and it seems to be less of the Palladian than of the nothing in particular—it is unobtrusive and comfortable. And when on a summer's day its departure platform is busy with luggage and passengers bound to the West, a pleasanter picture will be sought in vain.

But somehow there is never much stress at Paddington ; the work goes easily and without fuss, for the traffic is a level one. Not so that of the North-Western or the Northern, particularly in August. Those who would see station work at full power should look in at Euston on the eve of St. Grouse, or an evening or so before, between, say, seven and eight.

Slowly the empty train runs in from the cleaning shed eleven miles away. The paint is as bright as new after its rub down with paraffin, and the glass is without a smear after the abundant sousings from the Willesden tanks. The North-Western chiefs are fully alive to the

value of a good advertisement, and keep their expresses quite up to the standard of the locals they send as object lessons on foreign lines. That standard is a high one. Even at Victoria the trimness of the occasional North-Western train is noticeable, at Waterloo it is more apparent, at Herne Hill the dingy Chathams make it painfully obtrusive, and at Croydon it and the South-Eastern curiosities seem to have come from different worlds. Of course it is a cheap triumph, but it is a legitimate one.

The train, then, appears at the platform, a thoroughly respectable, workmanlike 'turn-out,' to use the familiar expression of the road—and, by the way, had we spoken of 'coaches' instead of 'carriages' we should have been more technically accurate. What are its colours? Chocolate and white, we are told; but the railway nomenclature of colour is not always the popular one. The Midland engines, for instance, are officially described as 'brown,' and the South-Eastern coaches are 'Wellington brown,' the colour being that of the Duke of Wellington's livery, and having been adopted to tempt the old hero, who then lived at Walmer, to take a ride on the new line. Great care is exercised in keeping these colours true. At Wolverton, at Swindon, at Derby, and the other great carriage works, there are steam grinding-mills constantly preparing the colour to pattern. Railway carriage painting is like roadway carriage painting and house painting as practised in Holland; it means an indefinite number of coats, pumiced and sand-papered and laid one on the other, till the proper gloss is attained.

There have been many suggestions as to the colour of railway coaches. The prevalent notion is that each company should have its own combination by way of

advertising its existence, but there are not wanting some people who insist that every class should have its colour, and some even go so far as to require that the carriage should be the colour of the ticket. If this were adopted, unless the whole ticket system were to be changed, the painters in oil would find their occupation gone, for the only way to meet the demand would be with distemper. The coaches would be a different colour on the up journey from what they would be on the down; coaches for return tickets would be half and half on the outward run and single coloured on the other; and excursion ticket-holders would be accommodated in the loudest of nigger stripes to start with, and in stripes of a totally different pattern for every day in the week on which they would return. And yet, gay as all this would make the trains, they would not look any more startling than did the Rocket, the Novelty, and the Sanspareil, when gorgeous in bright jockey colours they ran their great race at Rainhill.

When a train is in a station it is under the control of the station-master, and should it not have been lighted it is his duty to have it done. The miserable oil lamp is now making its last fight on the heavy lines. The North-Western have over 20,000 of these lamps in use, but they are diminishing monthly, and no one regrets them; and the fragrant old lamp-rooms with their slate tables and sawdust bins are getting themselves into trim for quite another duty. The substitution of petroleum for rape saved the Midland £10,000 a year; the substitute for petroleum will save them more. Oil, mineral or otherwise, has almost disappeared from trains that consist of the same carriages throughout the run. For single carriages and branch lines oil has its advantages, and a lampman's carelessness may still make travelling

a misery. From York to King's Cross we once journeyed in the dark. At Grantham we asked the guard for a light. 'You've got a lamp, can't you see it?' was the reply. 'No,' we answered, 'but we can smell it!' But neither guard nor station-master could appreciate third-class humour.

It is by oil-gas that most of the lighting is now done. The manufacture is much on the same lines as that of coal-gas. The petroleum is squirted as a spray into red-hot retorts to be vapourized, and passed through a hydraulic main to the condensers, and on through a scrubber to the gasholder. Thence it is pumped into a reservoir at a pressure of 150 lbs. to the square inch, and thence by means of the main it is admitted into the cylinders under the carriages at a pressure of 110 lbs. Two of these cylinders, thirteen inches in diameter and sixteen feet long, hold enough for a journey from London to Aberdeen and back, the gas being reduced to burning pressure by a system of regulators.

Some years ago the Brighton Company introduced electric lighting for their Pullman train. The electricity was obtained from accumulators which were charged from a dynamo at Victoria. Now there is a dynamo in the guard's van driven by the axle of the wheel, a compact contrivance, dynamo, accumulators and all being contained in a cupboard occupying but two feet of the length of the van. The Midland is also running electrically lighted trains; in fact, the electric light is making many friends on every railroad on which it has been introduced, and though the systems are many, the results are in almost every case satisfactory to the public, though not perhaps to the shareholders. But every year more economical methods are introduced, and we live in hope that a bright, cool light will become universal.

Another of the station-master's duties is to see that the carriages are properly warmed. The old hot-water foot-warmer has received notice to quit. Acetate of soda is the new solution, the advantage being that while water has to be put on the fire to be reheated, all that acetate of soda requires is a good shake. The acetate is liquefied in an iron tank, and seven quarts of it poured into each warmer, together with seven ounces of water and two cast-iron marbles. The warmer is then boiled up in another tank to be fit for use. It cools slowly, and before it is quite cold it is only necessary to shake the marbles about to restore it to a comfortable temperature. In the Midland, North-Western, and other sleeping saloons another system is in vogue, the carriages being warmed by high-pressure hot-water pipes.

Among the next improvements in the conditions of night travelling we shall probably have the abolition of the practice of waking up the passengers at the more important junctions. It has been found to be within the powers of human ingenuity to avoid an examination of tickets at four o'clock in the morning, and on one line it is reported that the porters have received instructions to announce the names of the stations in a considerate whisper. Why it is necessary for porters to shout at all is not very clear, and that the practice, even in daylight, is of any value may be doubted.

A good paper might be written on porters' cries, treating them under their several varieties as modified by local and individual circumstances. We have heard of the music of the waters as heard at Niagara : why not the music of the porters as heard on the Great Western ? How varied are their accents and intonations ! We can hardly expect a porter to be an elocutionist, but there might be a trifling pruning of his excrescences. The

late Sir Daniel Gooch once put a stop to the exasperating misuse of the aspirate in an admirable manner. 'Hacton! Hacton!' roared the man. 'Dear me!' said the chairman of the Great Western from the railway carriage; 'let that fellow be transferred to Hanwell; he can't give us too much $\frac{h}{2}$ there.' If the station had been Ealing instead of Hanwell the story would have been even better, for it so happens that Ealing, formerly Healing, has dropped the aspirate which has been so strangely picked up by the ancient Anwell.

Passing through Newton Abbot we once overheard a discussion on porters' cries. It seems they are fairly divisible into three groups. There are the mere grunts, as at Havant and Yeovil; the abbreviations, as at 'Snks' (otherwise Sevenoaks) and 'Drm,' 'S'num,' 'St'rum,' and 'Bl'um' (as at Durham, Sydenham, Streatham, and Balham); and the jubilantly rhythmical, as the 'Woodleywoodleywoodley Junc.' of the M. S. and L., and that glorious crescendo of the Midland, 'Mangotsfield! Mangotsfield! Change here—for Glaster and Chaltenam, Woster and Barmingham, Darby and the Narth!'

The carriages, having been cleaned and lighted and warmed, have also to be examined to make sure that the wheels are sound and the axles properly lubricated. This task is, as a rule, gone through behind the scenes before the train is backed into the departure platform, but at the stations on the road it has to be done in public. For express work oil is being increasingly used; it flows more quickly, and is altogether better, so long as the wheel is on the move. But when the wheel stops the oil's very fluidity results in the squeezing out of the lubricant between axle and bearing, so that the wheel starts 'dry,' and requires more engine power to move it.

The old yellow mixture of palm oil, soap, soda, and tallow is not so squeezable, and with it the friction at the moment of starting is less ; and hence our expresses are beginning to be lubricated with oil, and our stopping trains and goods trains with grease. Time was when the companies oiled their bearings with a lump of tow at the end of a hazel wand ; but they do not do so now. It is not often that anything is found wrong with a tire, but twice in our travels we have seen a carriage taken off a train because the metal did not ring true. And as to the greasing, we once saw a case of workmanlike thoroughness in work which has ever since given us an interest in that generally despised occupation.

Some years ago we were in the last carriage of an express that had stopped at Bedford. The wheels had all been tapped and rang true, and clicking up the lid of each axle box, the greaser was coming along the train. It seemed a mere matter of form, this lid-lifting. Click ! click ! wheel after wheel all right ; and as the clicker reached our carriage the guard started us. The wheels began to move ; the greaser clicked the first—but the box was dry !

What did he do ? Let it pass ? By no means. In a moment his tray was on the step, and he was on after it. As the express at fast-increasing speed ran out of the station, he threw up the axle-lids. By the time he had finished we were over the Ouse. Throwing his tray off, he sprang after it, and saved himself from falling by a long staggering run.

A very ordinary performance of merely a greaser ! But the present writer is of the same opinion now as then, that the man did his work at the risk of his life, and the work was not too humble to be done by a hero.



THE DUNALASTAIR.
(From a photograph by J. Turnbull.)

CHAPTER V.

THE ROAD.

IT takes a good road to stand three hundred tons pounding over it every few minutes, at fifty miles and more an hour. Stand on a bridge, and look down on a railway. See the four bars, planished by the heavily-weighted wheels, gleaming in the sunshine, and stretching away till they almost meet in an apex in the distance. There is not a weed or fragment out of place to break the monotonous floor of ballast. All is as clear as if newly swept. Were the railway under glass it could not look tidier. To keep 18,000 miles of line as clear as that is not an easy task. What a number of sources of rubbish there must be ! Even the vegetation is a serious matter, although nothing like what it is in warmer climes ; in South Australia, for instance, where it costs £16,000 a year in merely weeding the permanent way.

The keeping of the permanent way up to a high standard of efficiency is a most important matter in railway management. On a great line like the North-Western there is a man in charge of every mile of single track, or rather there are three men and a ganger to every two miles of double track. Over every ten or so of these gangs there is an inspector ; over every seven or eight of these inspectors there is a chief ; and so many of these chiefs are responsible for a division, in charge of a civil engineer.

Every day every foot of the track is gone over, and carefully examined, and it is by the gangers and their platelayers, together with the artisans of the division, that the works of the line are kept in repair. A humble task is that of a platelayer, but if his work were done in a slovenly manner there might be serious loss of life.

A railroad is always in danger. Rain and wind may damage embankments, rain and frost may cause landslips and block the rails, mining and brine-pumping may cause subsidences, wind and flood may cause bridges and viaducts to slip and settle, carriages and trucks may break down, cargo may fall overboard. And all these things come in the ordinary day's work. In the extraordinary day's work comes a disaster like that at Llandulas, where, in a Sunday storm, a viaduct was washed clean away, and a break made in the traffic between England and Ireland. Here was a state of affairs requiring all the strength of a great company. Within the week the line was taken half a mile inland, so as to cross the river over a temporary trestle bridge, being cut in the slope of the old embankment and run in places upon stacks of sleepers, so that there might be no settlement under the heavy traffic. Down to the bridge and up again the gradients were 1 in 23—a nice task for heavy trains, some of which took three engines to get them over! Yet the working went on without breaking the couplings or heavily bumping the carriages together; no mishap occurred, and 'the passengers in the train were scarcely aware that they were travelling under unusual conditions.' Meanwhile the new viaduct was in progress, and it was opened within the month, its forty-two girders, each thirty-two feet in length, having been rolled and worked at Crewe within a week.

The North-Western is the only company that does all its manufacturing, from rolling many of its own rails up to

fabricating artificial limbs for the injured members of its staff. Crewe can turn out 45,000 tons of rail a year, and does actually produce 25,000. But the works have been often described; and, like the making of the steel, the rolling of the rails, and the building of the carriages, they can have no place here. No carriages are built at Crewe, but almost every other branch of railway work can there be seen in progress, and among the unexpected things is the making of steel sleepers, of which there are now a hundred thousand on the line.

The sleeper of to-day is of wood; the sleeper of the future is to be of steel or a steel alloy, to resist an acid atmosphere. The Great Central does not 'pickle' its wooden sleepers, but nearly all other lines do. We hear of sleepers being 'cyanized,' or treated with corrosive sublimate; 'burnettized,' or treated with zinc chloride; 'boucherized,' or treated with copper sulphate; 'vulcanized,' or heated by steam and compressed; and 'creosoted.' In this country we generally 'creosote.'

If the traveller by the Great Western will glance south of the line as he crosses the canal at Hayes, he will see what looks like a gigantic box of bricks, laid out in towers, and tunnels, and bridges, and cubes, just as if some boy had been amusing himself playing at railway stations. This huge timber-yard, in which all the timber is of one size, shape, and kind, tails off into what looks like tar works, and it is in these tar works that the 'pickling' is done. But the Great Western sleeper yard at Hayes is a small affair compared to the Midland yard at Beeston, where a quarter of a million sleepers pass through the pickling process every year.

A sleeper is, nominally, nine feet long, really it is an inch shorter; it is ten inches wide, and half as thick. The first thing that is done to it is to put it into a machine, which bores in it the holes for the bolts and

trenails. As all these are done at once, there can be no variation in distance, and no doubt as to gauge. Then the sleepers are piled up on a truck in a circular stack, and six of these trucks, containing about three hundred altogether, are run into what looks like a gigantic boiler. As soon as they are in, and the big tube closed, the air is pumped out, and into the vacuum the creosote flows : then more creosote is pumped in under a pressure of 120 lbs. to the square inch ; and when each well-conducted sleeper has absorbed two gallons and a half into itself, the pumps are shut off, and the pickling is complete.

On the North-Western the creosote driven into the wood is half as much again, and the block complete as laid on the ballast weighs 160 lbs. To each sleeper there are two cast-iron chairs, each weighing 45 lbs., which are fastened in by two iron spikes and two galvanized iron screws ; and between the chair and the sleeper is a layer of hair felt. There is a sleeper to every yard of track. Concerning these chairs we might say much, but not now. At Derby one of the sights is the casting of chairs in a large shop specially devoted to the purpose. It does not take long to make a railway chair ; a man can turn out one a minute without exerting himself over much. There is the wooden mould with the brass clips for the returns ; down goes the mould, in go the clips, round goes the sand, out comes the mould, in goes the metal, there is a little smoke, a little flame, and the chair is complete. Like everything on a railroad, it is of special design. Rails, chairs, fish-plates, bolts—everything on the line differs in some slight degree from what is used by other companies.

A very casual glance will show that each line differs. The Great Western track from London to the West has its three rails, the extra one being for its abandoned broad gauge traffic. The Great Northern lays its inner

and outer rails alternately, so that the sleepers come at equal intervals ; it also banks up its ballast so that little more than the top edge of the rail is visible. The Great Northern itself is not a large affair ; it is its connections which give it so much importance. On the main line it goes no further north than Shaftholme, just outside Doncaster. There the North-Eastern metals begin, which stand clear out of the ballast, as the traveller to the North is only too well aware by the increased noise made by the carriage as it rushes over them. The Great Western was originally laid on longitudinal sleepers ; a plan which did very well on the level, but did not answer satisfactorily on a gradient, owing to its keeping the rail too rigid ; for, strange as it may seem, the very slight amount of spring between sleeper and sleeper gives the wheels a firmer grip and helps the train to climb. Where steadiness is an advantage, as over bridges and viaducts, longitudinal sleepers are still used ; and for the same reason rails are used of extra length. On the North-Western there are ten miles of line laid with sixty-foot rails.

But we shall never get away from these sleepers, and chairs, and rails ; and seemingly it requires an effort to avoid remaining in permanence on the permanent way. We have said nothing about the ballast, which has cost probably £400 per mile, and which on the Midland at any rate is sixteen inches deep in the middle of the six-foot. The Durango line in Mexico is ballasted with silver ore and laid with ties of ebony ; the Southern Pacific, across the Colorado desert, is ballasted with salt ; but in this country neither salt nor silver is cheap enough or lasting enough to ballast with, and we put our trust in the gravel and the 'breeze.'

A perfect road is level and straight, like that of the

South-Eastern between Tunbridge and Ashford ; but a country like the Weald is not to be found every day, and the engineer has to keep as near as he can to the ideal. In laying out a road it would seem to be the simplest plan to have one long arc springing from the termini and passing through the highest level ; but an arc of that nature, over an undulating country, is economically impossible, and it has to be cut up into subsidiary gradients, the object being to run these at such an average that the material removed from the cuttings will suffice to form the embankments. At the same time the general slope of the line, taken as between its highest and lowest points, is of considerable importance to those who have to run trains over it, and under the name of the ruling gradient it figures in many a discussion.

When George Stephenson laid out the Liverpool and Manchester, the line he floated on brushwood over Chat Moss, the ruling gradient he worked to was 1 in 900 ; the Birmingham and London line, which followed, could not be run to so flat an arc, and the Stephensons could do no better than 1 in 330 ; the union of these lines by the Grand Junction gave us the London and North-Western, which has the best road running out of London to the North. And yet, between Euston and Crewe, the North-Western has only 14 miles of level line out of the 158, though, curiously enough, on the 141 miles between Crewe and Carlisle there are 18 miles absolutely level, but of course these miles are not continuous. Throughout the distance from Euston to Carlisle there is rather more than a mile of curve to each mile of straight, the percentage of straight being 49. South of Crewe the steepest gradient up which the North-Western trains have to climb is 1 in 177, but through Cumberland they have to toil up 1 in 75 at Shap, and go over a summit of 915 feet, after several minor ups and downs ; and yet

through 50 miles of hills their average speed is $48\frac{1}{2}$ miles an hour, every ton of engine finding a sufficient load in two and a half tons of passenger train. North of the Border the Caledonian, which continues the North-Western route in Scotland, rises to over a thousand feet at Beattock, and dropping to 250, rises again over 880 before it reaches Edinburgh.

Its rival in the Scotch traffic, the Great Northern, has a worse road in the South and a better one in the North. Its ruling gradient is 1 in 200, and its summit is at Stoke, just a hundred miles from London, where it attains a height of 427 feet. From Shaftholme to Berwick its trains run on North-Eastern metals: between Berwick and Edinburgh they run over the eastern branch of the North British, the summit of which, at Grant's House, is only 367 feet, being 648 feet lower than the Caledonian.

The third road from London to the North is the Midland. Being the last comer it has had to take the best route that was left, and make a feature of its picturesqueness. Out of London it rises to Elstree; it runs from thence down and up to Leagrave, 367 feet; drops down to Bedford; crosses the Ouse seven times in seven miles; and rises 50 feet in a mile, and runs through cuttings 50 feet deep and over embankments 50 feet high till at Desborough it has climbed 435 feet. But this is nothing to what it accomplishes in the Lake country. There it climbs 1 in 100 for 14 miles, passes through Blea Moor tunnel at a height of 1,150 feet, drops with a run and rises again until it reaches its summit level of 1,167 feet at Aisgill. This is 252 feet higher than the North-Western and 740 feet higher than the Great Northern, and is the greatest height attained by any railway in England, except the Tebay branch of the North-Eastern, which goes over 1,320 feet at Stainmoor. The Midland reaches Edinburgh by means of

the Waverley branch of the North British, which runs by Riccarton and Melrose, and varied by a most difficult combination of hills and curves, rises to 1,000 feet at Hawick, and to 900 again north of Galashiels.

A very different road is that of the Great Western main line, which Brunel laid out so as to be as nearly flat as possible. Its summit level is at Swindon, where the line is only 270 feet above what it is at Paddington. The ruling gradient is 1 in 1,320; in fact, the line is practically level all the way to Exeter, the only noticeable descents being between Wootton Bassett and Dauntsey and at the Box tunnel, where it drops 1 in 100 for about two miles. Between Exeter and Plymouth the road becomes much more curved and varied, and before it reaches Penzance the curves, and banks, and astonishing viaducts become so numerous as to preclude any speed worth mentioning.

The London and South-Western has a much less favourable road to work. It is a line of long gradients and huge embankments. From London to Basingstoke it is fairly level, but beyond there the climbing begins, one bank, rising 1 in 250, being 17 miles long. At Lichfield, in the Hampshire ridge, the line is nearly 400 feet above the level of the rails at Waterloo. Between Southampton and Ilfracombe a level straight road could hardly be expected, though the engineers were more fortunate on that route than on the Portsmouth Direct, where circumstances led them to climb 460 feet up to Haslemere.

There is nothing on the South-Western like the thirty miles dead level which the Great Eastern possesses north of Cambridge, nor has it anything like the series of gentle ups and downs that mark the whole of the road from Liverpool Street to Norwich. What the Great Eastern suffers from is not a crippling ruling gradient,

but inadequate approaches for its enormous suburban traffic. As a contrast to it in many ways we may mention the struggling Chatham and Dover, which has the worst road out of London. For twenty-seven miles it runs up and down, chiefly up, to Sole Street, then it undulates, chiefly down, to Canterbury, up again it goes to Shepherds-well, to come down again to sea-level at Dover. Unfavourable as this road may be for quick passenger traffic, it is not nearly so bad as that of the old Manchester, Sheffield, and Lincolnshire, now known as the Great Central, and yet on that line there are more expresses than on any other in the kingdom. If the Chatham has the worst of the London roads, the Brighton has the best. Beyond gentle rises to each of its three tunnels, Merstham, Balcombe, and Clayton, and short inclines up to Grosvenor Road and Balham, its track from Victoria to Brighton is practically level, and has nothing about it to prevent 'five miles an hour easy' being added to its fastest running when its dividends begin to drop, and its bridges again come comfortably within the Board of Trade margin. And as to bridges in general we must have something to say.

The opening of the Forth Bridge led to much inquiry as to the size of its fellows. Which was the largest bridge in the world—that at Queensferry, that at Sukkur, or what? A question that could not be answered off-hand, as bridges are of so many kinds in plan and material.

The bridge that Horatius kept so well was built of piles in fours driven into the bed of the Tiber, with planks laid from one group to the other—a very early pattern. Those of the Chinese were suspension bridges of bamboos—a device that would seem to have come in later ; while there is across the Sutlej a bridge said to be

quite as old as Ancus Martius, which is actually a cantilever with 50 feet embedded in the masonry, 50 feet projecting, and a centre beam filling up the gap.

The most curious bridge we have in England is at Croyland, in Lincolnshire. It is a Gothic bridge, built in 1380, in which three roadways meet in the middle. Where it stands the Welland River divides into two branches, and the bridge has thus to provide for three water-courses as well as three roadways.

There is many a bridge with a story. As we have only space for one, let us take that of Pontypridd—we were going to say ‘of the bridge of Pontypridd,’ but Pontypridd means ‘the bridge by the mud-hut’ that stood close by on the bank of the Taff. William Edwards, the mason, began the bridge in 1746. He built it on three arches, and it lasted—not three years. One night it went away in the flood, the water rising over its parapet. Edwards built the second bridge—a single arch one, so that the flood might pass under unchecked. Unfortunately he laid too much weight on the haunches of his bridge, and too little on the arch; and one day the weight of the haunches forced up the crown, and the arch fell in, and Edwards was the laughing-stock of the country side. Never before had a bridge jumped up. However, Edwards had another try. To lessen the weight where it was not wanted he had the circular openings cut through the spandrils, and these he filled with charcoal—and in short, the bridge stood, and the holes we often see through bridges are put there in imitation of what Edwards did at Pontypridd.

Pontypridd Bridge, though curious from its story, can hardly be considered a perfect model. It had a very steep roadway when it was built, and though it has been improved it has a steep roadway now. There are a chain and a drag to be used. When a vehicle reaches

the centre of the bridge the chain is hooked on behind, and the other is hooked on to the drag, on which a boy obligingly seats himself, so as to take the weight off the horse, who might otherwise go down with a run. This is not an invention which has been largely adopted.

The object of all bridge builders now-a-days is to give a level road, and for that purpose iron and wood offer facilities which stone and brick cannot claim. Consequently all our modern bridges are of iron or steel, which is the commonest form of iron now used, and the principle of construction is chosen with regard to the work the bridge will have to do. Some bridges are 'suspension,' some 'tubular,' some 'bowstring,' some 'lattice girder,' some 'cantilever.' The Forth Bridge we have described at length in *Foundry, Forge, and Factory*. It is at present the longest and finest bridge in the world, and is on the cantilever principle, that is to say, it is 'a structure overhanging from a fixed base.' The river at Queensferry is divided by the island of Inchgarvie into two channels, whose depth of two hundred feet was thought to preclude the building of intermediate piers. On the three main piers are three double lattice-work cantilevers like scale-beams, each a quarter of a mile in length, reaching towards each other and joined at their ends by two ordinary girders 350 feet long. The bridge has two main spans of 1,700 feet each; two of 675 feet, being the shore ends of the outer cantilevers, and fifteen spans each of 168 feet. The total length of the road is a mile and a half, of which a mile is taken up by the cantilevers. The headway under the centre of the bridge is 152 feet at high water, and the highest part of the bridge is 361 feet above the same level. The main piers are cylindrical columns of masonry 36 feet high, 49 feet in diameter at the top, and 55 feet in diameter at the bottom, standing on rock or boulder clay. The canti-

levers are each bolted down to each column by forty-eight steel bolts $2\frac{1}{2}$ inches in diameter and 24 feet long. In the under-water work coffer dams were used for the shallow depths, and caissons with compressed air for the greater depths at Inchgarvie and Queensferry.

Whenever possible, a bridge is built on solid rock. If no rock is available a 'coffer dam' is used to give an artificial foundation. The coffer dam is merely a water-tight tank, sunk full of water on to the bed of the stream, where the water is pumped out and the foundation and masonry built within it. If the coffer dam is impossible, recourse is had to 'piles.' A pile is a beam of wood or iron driven into the ground by a series of heavy blows generally given by a 'monkey,' which monkey is merely a mass of iron dropped on to the top of the pile, much as if it were a hammer-head, the blows being of moderate force, it having been found that many light blows do the work more effectually than a few heavy ones.

In sand the piles are now generally sunk by means of the water-jet. An ordinary gas-pipe is fixed alongside the pile, and sunk with it. A powerful pump is fixed to the upper end of the pipe, and the water forced downwards clears the sand away below the pointed end of the pile, and down go the pile and the jet together. The jet must never stop until the pile is in position, for the water rising upwards around the pile renders its descent as easy as if it were greased. As soon as the pumping ceases the sand settles around the pile, and firmly secures it. Sometimes the water is driven down the hollow pile and squirted out at the point, so as to clear the sand away before it. Occasionally piles are fitted with screws, and screwed down into the sand, as doubtless our readers have seen done in many of the piers along our coast.

But of late the foundations of our larger bridges have been put in by means of the 'caisson'—familiarily pro-

nounced cassoon—which is merely an adaptation of the principle of the diving-bell. The caisson is a room made of wood, with the bottom edges of the walls shod with iron. It is filled with air, and slowly sinks as the earth is dug into within it, the pressure of the air increasing as it descends, and being kept sufficient to prevent the water from making its way in. The men get into the caisson down a tube which has in it an ‘air-lock,’ the air-lock being simply a chamber with valves at the top and the bottom, on the same principle as a water-lock in which boats are lifted or lowered to different levels on our navigable streams. The lower valve is kept closed by the pressure of the air pumped into the caisson beneath. When the lock is entered the upper valve is shut, and the small valve connected with the caisson is opened, so that the pressure in the lock soon becomes the same as that beneath it, and then the valves open downwards, and until they are closed again the lock is part of the caisson. The fragments of rock are either removed through this air-chamber, or else through hose. Owing to the air pressure, no pumping is required in its removal. A pool of water is made in a corner of the caisson in which the materials removed are kept in suspension, and when the tube is introduced into this water and the tap turned on, away go water and all up the hose like a fountain ; but, notwithstanding the convenience of this arrangement, it is obvious that the air would soon be exhausted were it persisted in, and consequently a sand-pump is generally used, which acts on the same principle as that of the injector in steam boilers. The water is forced through a tube which near the inlet surrounds another tube up which the excavated earth is driven with such surprising velocity that at night the friction of the particles makes the issuing stream a gleaming cone of fire. Some caissons have been sunk to enormous depths. On the St. Louis

River, in the United States, one went down over a hundred feet below the water-line. This is not the greatest depth of bridge foundation building by any means. In Australia a depth of 175 feet was reached by the 'open method,' which is really the principle of the coffer dam extended, section after section being added on the top as the excavation proceeds below.

Since the publication of the design for the Forth Bridge every long span bridge in the world has been built on the cantilever principle. One of the most interesting examples of the cantilever in a modified form is that at Niagara, just below the great falls. The floor of this railway bridge is on the top of the structure all along. It is 239 feet above the surface of the water, which has a velocity of over sixteen miles an hour in the centre, and forms constant whirlpools near the shore. The shore-arms of the cantilevers are firmly anchored to piers built on solid rock. The river arms were built piece by piece, each piece being more than counterbalanced by pieces stretching shorewards until completed, and then joined by a short truss, the workmen carrying on their labours on a platform hung from a projecting skeleton structure over the Niagara River. In the Lachine Bridge near Montreal the cantilever principle has also been applied. The bridge has a length of about 1,200 yards, with two channel spans, each of 408 feet. These spans and the spans next to them form cantilevers, and were built out from the central pier without the use of 'false works' in either channel.

Of a different principle is the great bridge across the Mississippi at St. Louis. There are three steel arches, the centre having a span of 520 feet, and the side arches having one of 502 feet. Each span has four parallel arches, each arch being composed of cylindrical steel tubes 18 inches in diameter, acting as chords of the

arch. The tubes are twelve feet apart, connected by a single system of diagonal tracing. The bridge was a most difficult one to build. The headway is 55 feet above ordinary high water, but the variation between low and high water has been over 40 feet. The river, which has a very variable current, holds much matter in suspension, and even its bed is in constant motion. Captain Eads, the designer of the bridge, went down in a diving-bell, and found a moving current of sand below quite a yard in depth. At low water this bottom rises, but as the stream fills a scour sets in, and the bed is quickly deepened ; while in winter the river is closed by huge cakes of ice, which freeze together into great fields. The only safety for the bridge, therefore, lay in getting down deep enough to build the foundations on the underlying rock.

Another notable bridge is that of the Cincinnati Southern Railroad across the Kentucky River, which runs through a canyon 1,200 feet wide and 275 feet deep, in which it has been known to rise as much as 40 feet in a single night. There are three spans, each of 375 feet, carrying the railroad 276 feet above the river. The ironwork is 1,138 feet in length. The piers are of stone to a height of 60 feet to clear the highest floods, and on them the iron framework is built. Each iron pier is 177 feet high, and consists of four legs, terminating at the top in a turned pin a foot in diameter under each of the two trusses. The trusses were built out on each side until they joined in the centre and at the bluffs. When the junction was made they were continuous, but to avoid the constant strains it was ingeniously decided to cut the bottom chords of the side spans and convert them into sliding joints at points 75 feet distant from the iron piers. The expansion and contraction of the bridge operates each way from the

centre, bending the tops of the piers towards or away from the bluffs. The ends of the girder rest on rollers at the abutments, and can travel three inches under changes of temperature.

This resting of bridge ends on rollers is a contrivance well known to all who have been through the Britannia Bridge across the Menai Straits on their way to or from Holyhead. The daily variation of this bridge is from half an inch to three inches along its whole length. A short spell of sunshine on the top will raise the roof an inch in half an hour, the top plates being expanded by the increase of temperature, while the lower plates are kept cool by radiation to the water beneath. By the sun shining on one side the tube is drawn sideways for half an inch, to return to its original position as soon as the sun is clouded over. Sometimes in the sunshine the tube will move $2\frac{1}{2}$ inches vertically or horizontally!

The Britannia—so called after the Britannia rock on which the central pier rests—is a tubular bridge. It was Fairbairn who first saw that a girder might be made self-supporting, and on this principle the bridge was built. It consists of two independent continuous wrought-iron tubular beams 1,510 feet in length, and each weighing 4,680 tons. These rest on two abutments and three towers, at a height of a hundred feet above the water. The conditions imposed by the Menai people were intended to make the building of the bridge impossible. No scaffolding was to be used and no interruption to the traffic was permitted, and the tubes were put together further up the channel and floated down, and raised into position by hydraulic power. The building of this bridge was one of the greatest feats of modern engineering, and when the first train went through it, great was the relief of its builders. ‘Often at night,’ says Robert Stephenson, ‘I would lie tossing about, seeking sleep in vain. The

tubes filled my head—I went to bed with them, and got up with them. In the gray of the morning when I looked across Gloucester Square it seemed an immense distance across to the houses on the opposite side. It was nearly the same length as the span of my tubular bridge.'

The Victoria Railway Bridge over the St. Lawrence at Montreal, recently condemned as too small for the traffic, and now being replaced by the Victoria Jubilee Bridge, was also built by Robert Stephenson on the same tubular plan. It was a mile and three-quarters long, and the single line of rail was 60 feet above the river level. In the tubes there were over 9,000 tons of iron; the surface to be painted exceeded thirty acres, and the annual crop of rust which had to be removed was very large. Tubular bridges are not cheap, and the cost of their maintenance is great, so that no more of them are likely to be built; but it was to them we owe the first introduction of wrought-iron in long spans upon railways.

At Niagara Falls is another of the world's great bridges—Roebbing's railway suspension bridge, completed in 1855, which has a span of 821 feet, and a track 245 feet above the stream. With this bridge a very remarkable operation was performed several years ago. The stone towers holding the huge supporting cables—each cable has 3,640 wires—were disintegrating, owing to the rollers over which the cables passed having become jammed so as to prevent the cables moving freely over them, and thus throwing additional strain on to the masonry. To relieve the towers, skeleton iron towers were built up round them, and the cables were transferred from the stone to the iron by hydraulic arrangements without interrupting the traffic across the bridge!

The great suspension bridge between New York and Brooklyn is one of the world's wonders. It has a central

span of nearly 1,600 feet, two land spans each of 930 feet, and with its approaches is over 1,100 yards long. The road is 135 feet above the water, the towers are 272 feet above high water, and on them are hung four cables supporting two carriage ways, two lines of railway, and an elevated footway which between them weigh nearly 7,000 tons.

The Menai Straits are famous in bridge history. The tubular bridge started there, and it was Telford's bridge, opened in 1825, which led to the general introduction of the suspension bridges, which in the Brooklyn example has reached such excellence.

There is one danger in suspension bridges that has not yet been entirely overcome. When the weight is on one half of the bridge the other half rises, owing to the pull of the cable, and any rhythmic motion has a tendency to shake the roadway to pieces. At Angers, in 1850, a suspension bridge gave way when 487 soldiers were marching across it, and 226 were killed by the accident. Had they 'broken step'—that is, walked irregularly—this would not have occurred.

Military bridges are usually on boats or pontoons; but boat bridges are not always for military purposes. There is a well-known floating bridge across the Royal Canal at the Broadstone terminus of the Midland Great Western Railway of Ireland, which is anchored by allowing water to fill its tanks and removed by syphoning out the water, so that it floats and swings to let the vessels through. The longest floating bridge in the world is across the Hooghly at Calcutta, which is 1,530 feet long. At the Dublin Royal Canal there is another bridge worthy of note. This is a 'lift' bridge, which is raised by hydraulic power for barges to pass under. There is a lift bridge, rising at the four corners, in London, over the Surrey Canal.

The Tower Bridge is a 'basculé,' or drawbridge, and the largest of its class. In the river stand two massive Gothic towers, 200 feet apart, connected by a footway between their top stories at a height of 135 feet above the Thames, and by the drawbridge on a lower level, which is $29\frac{1}{2}$ feet above high water; over all the bridge is 800 feet long.

A more usual style of bridge for navigable streams is the 'swing bridge,' of which there is an example in New Jersey, allowing two free passages, each 216 feet wide. Sometimes a 'traversing bridge' is used, and of this construction we have an example near Ford, where the London and Brighton line crosses the Arun on a folding arrangement 144 feet long. There is a well-known swing bridge at Newcastle-on-Tyne, and close to it is the High Level Bridge, affording so fine an example of the bow-string arch. The roadway for carriage and passenger traffic runs along the string, while the railway runs overhead on the tops of the bows.

The first cast-iron bridge was built over the Severn by Darby in 1779, and the town of Ironbridge sprang up around it. The largest of cast-iron bridges is that at Southwark, built in 1824, across the Thames. It is of three arches, and is 42 feet wide and 718 feet long between the abutments, the centre being the largest cast-iron arch in the world. Another cast-iron bridge is Vauxhall. The other London bridges are of wrought iron, the most remarkable perhaps being Charing Cross, which is a lattice bridge just over a quarter of a mile long, the cylinders of which were loaded with 150 tons to sink them in the clay, and were then filled with concrete and brickwork, and under a load thus increased to 700 tons they sank four inches more before they were ready for the road.

But something should be said as to the way in which

the roads are made. An innings must be found for the navvy. Between Dore and Chinley is what was one of the most difficult lines in England to make. It is only twenty miles long, but it cost more than a million of money. It gave the third road through the Pennine Range between Sheffield and Manchester. Through that range on the same errand there first went the Great Central, who drove through it the Woodhead Tunnel, 5,297 yards long, which at the time was the longest in England—a terribly hard piece of work, mostly through millstone grit, in which 157 tons of gunpowder were used for blasting; and differing from other tunnels in being in duplicate, one bore being for the up traffic, and the other for the down. On similar thoughts intent—the thoughts of sharing in the Sheffield and Manchester trade—came the North-Western, who went through the ridge by the Standege Tunnel of 5,342 yards, which, by eclipsing the Woodhead, became the premier tunnel in England, until that under the Severn, 7,644 yards long, put it very considerably in the shade. And then came the Midland, by its branch from Dore to Chinley, going through the same ridge as the North-Western and Great Central, and that by Totley Tunnel, 6,200 yards long. This huge bore, which is under Longshawe Moors, opens into the valley of the Derwent; and no sooner has the new line crossed that picturesque stream than it bores again for 3,600 yards through the limestone of the Peak to join the main Midland to Manchester, a little north of Chapel-en-le-Frith.

Next to the Woodhead in length comes Bramhope, 3,745 yards, on the North-Eastern, followed by the Medway Tunnel, only five yards shorter, on the South-Eastern, which is just fourteen yards longer than that at Festiniog on the North-Western. The Sevenoaks Tunnel, on the South-Eastern, measures 3,600 yards. The Box Tunnel on the Great Western is only 3,227 yards long,

but it is one of the wonders of the West, as those who have visited the quarries and walked into it can testify. Unlike other tunnels, it is not lined throughout, owing to the exceptional nature of the rock through which it is driven. Where the fuller's earth and clay are met with there is the usual state of things, but in the freestone beds there is a huge cavern half a mile long, forty feet high and thirty feet wide, roughly shaped as a Gothic arch. The dip of the road is from east to west, the dip of the rocks is from west to east, and there, at a gentle slope, they stand in huge joints and strata, rising as on corbels to the under side of the uppermost visible bed, which has been left as a flat narrow roof.

Very differently do we think of tunnels now to what our fathers did when this at Box was made. Then the plunge into the hill was deemed to be so prejudicial to health that doctors advised their patients on no account to adventure it. And in Yorkshire the feeling against travelling underground was so strong that a commission of medical men was appointed to inquire into the effects on the human constitution of 'the Leeds, and Selby, and other tunnels.'

On the St. Gothard Railway, not far from the famous long tunnel, there is a remarkable tunnel on the plan of a corkscrew. In the descent of the mountain it was found impossible to lay out a safe incline on a straight line or ordinary curve, and the engineers got over the difficulty by driving a tunnel which enters the mountain high on the side, describes a circle through the solid rock, constantly descending as it does so, reappears under itself on the mountain side some distance below, then dives into the rock, again circles, and sinks as it circles, until it again emerges into daylight under itself, when the line resumes its course down-hill in a more familiar way. The making of a tunnel like this is as

striking an example of engineering skill as the world can show, and many very skilful things have been done by our railway makers.

The art of tunnelling is an old one, but it never attained such perfection as distinguishes it to-day. A tunnel was driven under the Euphrates in the days of Semiramis, but before that period, even in prehistoric times, two tunnels were driven for the drainage of Lake Copais, which was cleared of obstructions in B.C. 330. About B.C. 540 Eupalinus of Megara drove his tunnel at Samos through a mountain 900 feet high, which was nearly a mile in length. But the most remarkable of these ancient works was the tunnel driven in the days of the Emperor Claudius connecting the Lake of Celano with the river Siris. This tunnel, which was cleared out about fifty years ago, is three miles long, twenty-eight feet wide, and nowhere less than twenty feet high; it passes in places through solid rock, and in other places is lined with masonry, and seems to have been made in much the same way as our modern railway tunnels, the excavation having been carried on simultaneously at different places along its length by means of vertical shafts and inclined galleries from the sides of the mountain.

In more recent times a tunnel for a somewhat similar purpose was excavated in America. To drain the Valley of Mexico, which has no natural outlet, there was begun in 1603 a tunnel more than six miles long and ten feet wide. 'It was driven,' says Mr. Bogart, 'through the formation called tepetate, a peculiar earth with strata of sand and marl. It was finished in eleven months. At first excavated without a lining, it was afterwards faced with masonry. It was not entirely protected when a flood came, the dykes above gave way, and the tunnel became obstructed. The city of Mexico was flooded, and it was decided that, instead of repairing the tunnel,

an open cut should be made. The engineer who had constructed the tunnel, Enrico Martinez, was put in charge of this enormous undertaking, and others took his place after his death. The cut is believed to be the longest ever made in the world. For more than a century the work was continued. Its greatest depth is now two hundred feet. It was cut deeper, but has partially filled with the washings from the slopes. The cost was enormous, more than six million dollars in silver having been actually disbursed, and more than 100,000 Indians perished while engaged in the work.

There is a wonderful tunnel at Chicago, driven in 1852 two miles out under the bottom of the lake, so that the city may obtain a water-supply free from the refuse of the city. This tunnel, which has now been doubled, has two shafts, one on land and one in the bed of the lake, rising through a crib, which crib is defended by a breakwater, and serves as the foundation of a lighthouse. This was a difficult work to manage, owing to its being through clay and quicksand, but it is a mere nothing as to length. There is, for instance, the Croton Aqueduct from Croton Down to New York, which is driven through solid rock for $33\frac{1}{4}$ miles. The Hoosac Tunnel, of which we have heard so much, is $4\frac{3}{4}$ miles in length, and is 26 feet wide, and $21\frac{1}{2}$ feet high.

But we must recross the Atlantic, not, however, without extending our survey to Peru, where, on the Lima and Oroya Railroad, there are sixty tunnels in a hundred miles, the longest being on the summit of the pass through the Andes. This tunnel is two miles higher above sea-level than either the St. Gothard or Mont Cenis, and all the tools and stores and food had to be carried up the mountains on mule-back. At such a height the rarefaction of the air makes labour painful, and altogether this Andes tunnel is a most daring achievement.

When canals were introduced into Europe, tunnels became necessary to avoid excessive lockage, and with the railways tunnels became quite common.

In building the Box Tunnel the great difficulty was the water, a difficulty which is always present in subterranean work. In the Kilsby Tunnel, on the London and North-Western line, the water almost ruined the enterprise. The tunnel is 2,423 yards long, and runs at an average depth of 160 feet below the surface. Before the contract was given out the character of the subsoil was examined by trial shafts, which indicated that it was lower oolite shale. The works were let accordingly, but they had scarcely been begun when it was discovered that between the trial shafts there existed a quicksand under a bed of clay 40 feet in thickness which the borings had missed. At the bottom of one of the shafts the works were in progress when the roof gave way, a deluge of water burst in, and the workmen escaped with their lives by means of a raft on which they were lowered, by one of the engineers swimming with the rope in his mouth to the lower end of the shaft, out of which they were safely brought to the surface. The works were stopped, and the contractor who had undertaken the construction of the tunnel was so overwhelmed by the calamity that, though he was relieved by the company from his engagement, he took to his bed and soon died.

The Stephensons, George and Robert, took counsel together. George suggested pumping the water to the surface, while Robert thought a drift along the heading to serve as a drain might be of more use. Both measures were tried. One day, when the workmen were gathered round the entrance to the heading, there was a roar as of thunder. It was hoped that the water had burst in, but very little water made its appearance, and it was found that a mass of sand had fallen and choked up the passage.

There was nothing to be done but pump ; and for eight months the engines kept at work to clear out the millions of gallons of water at the rate of 2,000 gallons a minute. The water pumped out of the tunnel while the work was in progress would be nearly equivalent to the contents of the Thames at high water between London and Woolwich. Protected by the pumps, the men worked, as it were, between two perpendicular walls of sand and water. The bricks were often scarcely covered with cement ready for the setting ere they were washed clean by the streams of water that poured from overhead, and the men had to hold over their work large whisks of straw to protect the bricks and cement while the setting took place. The tunnel was estimated to cost £99,000 ; its actual cost was nearly £300,000.

With regard to this section of the London and North-Western Railway, a curious calculation was made at the time which is not without its lessons to those who talk so grandly of the past. 'The Great Pyramid of Egypt was, according to Diodorus Siculus, constructed by 300,000—according to Herodotus, by 100,000—men. It required for its execution twenty years, and the labour expended upon it has been estimated as equivalent to lifting 15,733,000,000 of cubic feet of stone one foot high. Whereas, if the labour expended in constructing the London and Birmingham Railway be in like manner reduced to one common denomination, the result is 25,000,000,000 of cubic feet *more* than was lifted for the Great Pyramid ; and yet the English work was performed by about 20,000 men in less than five years.'

The Kilsby Tunnel was not the longest driven by the Stephensons. That distinction remains with the Summit Tunnel, near Littleborough, on the Manchester and Leeds line, which measures 2,869 yards, and took four years in building, using up 23,000,000 bricks and 8,000 tons of

Roman cement, and occupying a thousand men. And here we may as well give the lengths of a few of our great tunnels. The Sapperton, on the Great Western Cheltenham road is 2,800 yards long: the Wapping, on the London and North-Western, at Liverpool, is 2,250 yards; the Lime Street, close by on the same line, is 20 yards shorter. There are four tunnels on the road to Brighton; that at Merstham measures 1,780 yards; that at Balcombe, the summit, 1,122 yards; the Clayton, 2,200 yards, and the Patcham, 480 yards. Sydenham Tunnel, on the Chatham and Dover, measures a mile and a fifth. Abbot's Cliff Tunnel, on the South-Eastern, at Dover, measures 2,000 yards; the Watford Tunnel, on the North-Western, measures 1,793 yards; Clay Cross, on the Midland, measures just a mile; Wickwar Tunnel, on the Midland road to Bristol, measures 1,320 yards. The Primrose Hill Tunnel, on the North-Western, measures 1,250 yards—a famous tunnel this. Owing to the mobility of the moist London clay, the pressure here on the brickwork was so great as to squeeze the mortar from the joints, and bring the inner edges of the bricks in contact: the bricks began to grind into dust, and the dimensions of the tunnel gradually grew less, until specially hard bricks were procured, which were set in Roman cement and built in ring upon ring until the arch was in most places twenty-seven inches thick. Bletchingley Tunnel, on the South-Eastern, between Redhill and Ashford, is 1,086 yards long; and Saltwood, further along on the same line, is 1,000 yards long. These two tunnels may be called 'classic'; it was about them and the appliances used in them that F. W. Simms wrote the treatise on tunnelling, which is still the text-book for that branch of engineering.

The longest tunnels of our day have been driven through the Alps. The St. Gothard took $9\frac{1}{4}$ years to build. It is $9\frac{1}{4}$ miles long, with a section of $26\frac{1}{4}$ feet by

over 19 feet. The miners had to work in it knee-deep in water ; in fact, the water poured in at the rate of 3,000 gallons a minute, enough to sweep men and horses away altogether. The Mont Cenis is $8\frac{1}{2}$ miles long ; it is through solid rock from end to end, and is 24 feet $7\frac{1}{4}$ inches high by 26 feet $2\frac{3}{4}$ inches wide, and in the last stages of the work, which took twelve years to complete, there were 4,000 men on it. The Arlberg Tunnel is $6\frac{3}{4}$ miles long. It was begun in June, 1880, and the first train passed through in November, 1883—a quick performance. In Germany, tunnels are numerous. On the Vienna and Trieste route the engineering is very daring. In the Black Forest there are twenty-nine tunnels within sixteen miles, most of them on the curve, and one of them a complete 'S' in shape. And there are several of the same shape on the Italian line across the Apennines from Bologna to Pistoja, where forty-six tunnels have been driven in a length of sixty-two miles.

The way in which a tunnel is made is easy to understand. Take the St. Gothard, for instance. A heading was driven along the proper line into the mountain. This heading was a horizontal shaft just big enough for the men to work in, and lay along the middle of the proposed tunnel, and in its upper half. Enlarged to the left to the full width for a short section, it allowed the left-hand side of the upper portion of the arch to be put in ; widened next to the right, it allowed the arch to be completed. With its floor cut down it gave the height of the tunnel, and allowed the rails to be roughly laid. The right side of the trench so made being cut away, allowed the right wall of the tunnel to be built up to the arch ; the left side being then removed gave the fairway of the tunnel and allowed the brickwork to be completed, the inverted arch joining the walls below being built last, where such an invert was required. All tunnels are

thus built in short sections, and enlarged from a heading, though often the heading is driven along the floor instead of along the crown of the work, as in this instance. The excavation is made as nearly as possible of the size and shape of the intended masonry, and every cavity outside the arch is carefully filled up. As a rule, the tunnel is begun at both ends at once, and often the work is also started right and left from vertical shafts along the line, very careful measurement and levelling being necessary to ensure a perfect join. This is not an easy matter when the tunnel is straight and on a gradient through-out; but when the road is of different gradients, and on a curve, the difficulty is enormously increased. It is rare, however, for engineers to be more than a few inches out, even in such a long run as the St. Gothard.

The greatest tunnelling work in this country has been done under water. We have had the Thames Tunnel, now on the line of the East London Railway. We have had the Mersey Tunnel, a mile long, uniting Liverpool and Birkenhead; and we have had the Severn Tunnel, 7,644 yards long, the most notable of recent railway works.

Of this tunnel, as being the best thing done of late years, we may speak more at length. It is under an estuary where the tides are the highest in Europe, being only surpassed by those on the Kennebecassis at the head of the Bay of Fundy, in New Brunswick. Between high and low water the Severn has a rise of 50 feet.

The tunnel was begun by the Great Western Railway Company on October 8, 1879, but the water broke in, and the men in a panic fled and left the doors open that had been placed to keep back the water in case of an inrush. After this disaster, Sir John Hawkshaw was called in to the rescue as chief engineer, and on December 18, 1879, the works were handed over, under

contract, to Mr. T. A. Walker. Desperate efforts were made to pump the water out of the works, but without success. Bigger and bigger pumps were employed, and they all by some unhappy chance broke down just as they were having effect on the stubborn stream. On July 2, 1880, a powerful pump, of which great things were expected, was got to work. Down went the water, down, down, until at half-past three the pump broke with a crash, and the water in a few minutes ran up to the same level as before. It was all very disheartening, but what could be done?

It was determined to shut an iron door which had been built by the company in the long heading under the river, about a thousand feet from the bottom of the shaft, which door the men in the panic at the first breaking in of the water had left open. This was a diver's work; and, on November 2, 1880, the attempt was made. But let us have Mr. Walker tell his own story:— 'The diver, to do this work, would only work under a head of 30 feet of water. He would have to walk up the heading 1,000 feet from the bottom of the shaft, drawing his air-hose after him; and when he reached the door he would have to go behind the door, which opened inwards, and shut down a flap valve upon an eighteen-inch pipe, come back through the door, pull up two rails of the tramway, close the door after him, and then screw down a twelve-inch sluice-valve, which was on another pipe on the north side of the door, when all communication with the further part of the heading under the river would be completely cut off.

'As it was impossible for one diver to drag so long a length of hose as 1,000 feet after him up the heading, three divers were engaged. One stood at the bottom of the shaft to pass the hose, which was floating hose, round the bend, from the shaft into the heading, the two others

then started up the heading for a distance of five hundred feet, when one remained to pull forward the hose and feed it to the leading diver.

'The leading man, in whom I had thorough confidence, was Lambert. He started on his perilous journey armed only with a short iron bar, and carefully groped his way in total darkness over the *débris* which strewn the bottom of the heading, past upturned skips, tools, and lumps of rock, which had been left in the panic of 1879, until he reached within one hundred feet from the door, when he found it was impossible to drag the air-hose after him, as it rose to the top of the heading, and its friction against the rock and the head-trees offered greater resistance than he could overcome. He, however, would not give up without an effort, and he pluckily sat down and drew more of the hose to him and then started off again ; but after one or two vain efforts he found it impossible to proceed, and was obliged to return to the shaft defeated.'

Then Mr. Walker happened to hear of the Fleuss diving-dress, and telegraphed for the inventor to bring it along with him. The apparatus is simply a sort of knapsack containing compressed oxygen, which communicates with a mask worn over the face. The inventor attempted to get to the door, but failed, being evidently unaccustomed to practical diving. Then Lambert was persuaded to try the new apparatus, and, after a day or two's practice, he made another trial along the heading. He reached the door and pulled up one of the rails. Two days afterwards he went again, and did the work complete, shutting the door and screwing the valves. He was away an hour and twenty minutes. Then the pumping began, and slowly, much more slowly than was expected, the water sank. When the water was low enough to allow a man to wade along to the door, the mystery of the slowness was solved. There were two valves, one with a

right-handed screw, the other with a left-handed screw. Lambert, not knowing this, had screwed both tight to the right hand, so that he had shut one sluice and opened wide the other !

The water for a time was checked, and the works began to advance rapidly. Again and again there were difficulties with the water. In 1883 it burst in at the rate of 27,000 gallons a minute, and Lambert, who had been out to Sydney to help to raise the Austral, had again to shut a door ; and once the tidal wave broke in and flooded cuttings and tunnel ; and once the approaches to the works were choked with snow ; but all difficulties were overcome. Quite a town grew up round the tunnel end, with hospital, schools, and mission-hall complete for the men employed on the works and their families. And at length, what with pumping 23,000,000 gallons a day, and using 76,400,000 bricks, and 36,794 tons of Portland cement, the 3,628 men succeeded, in seven years, in finishing one of the driest tunnels now in successful use.

If the Severn is our best tunnel, the Settle and Carlisle is our most remarkable line. It is just over seventy miles long, and it took over seven years to make, and cost over three millions of money. When it was being staked out the engineer and his men were snowed up in the Blea Moor inn. For three weeks the snow fell continuously, until it lay seven feet and a half thick, and it was only by driving a tunnel through the snow to the road that the men, who lived on a stock of eggs and bacon, got water from the horse-trough to drink. The making of the line was a very war with the giants. Along its whole length there was not a level piece of ground big enough to build a house on, and its embankments, cuttings, and tunnels had to go over or through almost

every variety of rock known to the lithologist. In the southern part of it is a section through boulder clay, the most unsatisfactory of materials for the engineer—one hour a thick soup, only removable in buckets, the next a stubborn rock; one day so hard as to require blasting by gunpowder, the next, owing to a shower of rain, a mass of glue. Further on is the real tough rock of the outlying flank of Whernside, Blea Moor, where 2,000 men were engaged for four years or more on embankment, tunnel, and viaduct, the wind being at times so high that the bricklayers could not work, for fear of being blown from the scaffold.

In driving the first heading for a tunnel, only four men can work in one place; now the greater the number of faces on which they can work, the more quickly is the heading driven; and hence not only is the heading bored from each end, but shafts are dug down from the top, each shaft giving two more faces to work at. At Blea Moor there were seven shafts, some of them of 500 feet and more, and thus an opening was made for sixteen gangs of men, night and day, four of the shafts being eventually left as ventilators. Once the heading was driven, the 'breaking up' was started on, that being the enlargement of the hole sufficiently to allow of the arch being put up in brickwork, the space behind the brickwork being filled in with loose rock. Then the excavation of the tunnel was continued down to the level of the rails, and the sides and floor put in. In all this work much gun-cotton and dynamite was used, and as this could not be sent by railway, it had all to be carted from Carlisle or Newcastle, at a cost of £200 a ton.

The next great tunnel to Blea Moor is that at Black Moss, and north of that is Intake Bank, where for twelve months the waggons daily tipped their contents without

the embankment advancing a yard. Chat Moss was bad enough, but Intake Bank holds the record amongst railroad absorbents.

Solid as an embankment may look, it has its peculiarities in weakness. All embankments suffer more or less from 'nerves.' In even the solidest, the vibration of a fast train can be detected a mile and a half off. Strange stories are told of embankments. At Wolverhampton there is one which suddenly began to smoke, and burnt for days, owing to the iron pyrites in the material of which it is made. At Hanwell, on the Great Western, the embankment was not on a sufficiently wide basis, and it burst right through the layer of clay, so that it took more material to repair its damages than had originally been used to make it. A serious matter is this of vibration. Some say that the vibration spreads farthest in the direction of the earth's rotation. A curious theory; though it is certain that on railroads the western rail wears out faster than the eastern, owing to the earth's motion pressing down one side of the train harder than the other.

North of the Intake Bank is the Birkett Tunnel, wherein there was once a fall of rock which left a cavity sixty feet high to be dealt with. The Birkett is a notable object lesson in geology. It runs through the Great Pennine Fault, and within the space of one hundred yards perforates shale, limestone, grit, slate, iron, coal, and lead ore; and in it the strata rise from the horizontal to the perpendicular. Farther north is the Smardale Viaduct, 130 feet from stream to rails, and 710 feet long, in which over 60,000 tons of gray limestone were used. But why continue this catalogue? To take another point of view, let us note that the next contract section of the line contained 47 cuttings, 5 viaducts, 4 tunnels, 68 road-bridges, and 100 culverts; that the rainfall was 92 inches

a year; and that although 2,000 men could only work on the section at a time, yet 33,000 passed through the wage list in the course of the undertaking.

Of the navvy and his life much has been written, and of what has been written much has been imagined. The navvy of to-day has far less about him of what it is fashionable to call the 'mere animal,' but he is none the less greedy of work, and his appetite is gigantic. Some enthusiastic temperance advocate has told us that the railroads of this country have cost us £1,000 a mile in drink. This means that they have contributed about £8,000,000 to the Exchequer in direct taxation. We doubt it. And certainly, during the last ten years, the rate of dissipation has been steadily lessening. The navvy has his friends and his foes. In many respects he might improve in his morals and habits. Have not 'steam navvies' been introduced to replace him—which have no morals at all, and no habits to speak of? But with all his faults he is not a man of whom his fellow-men need be ashamed. Rough, uncouth, childish though he may be, he is a very king to the man in the same condition of life on any railroad out of Britain.

There is one noble navvy story which is worthy of a place in our national note-book. It was at Bugsworth in Derbyshire, just north of Chinley, when the Midland was making. The mouth of the tunnel fell in, and a small gang of navvies were entombed. A short shaft was sunk, and in twenty-three hours the men were reached. They were found lying, almost dying, exhausted for want of air, and on the floor the candle was flickering in its socket, and in a few minutes would have gone out. The rescue was just in time, and when the men recovered they told a strange tale of one of the most prosaic of heroic deeds. They had been startled by the fall of

rock, and found they were shut in, and for a moment were in fear. And then one of them said, 'Well, chaps, we shall never get out of this alive, so we may as well go on with our bit while we can.' And to work they set, in what they had every reason to suppose was their tomb, steadily and quietly, as if they were in a cutting in the open. And they went on with their 'bit,' until the air failed them, and they sank exhausted.

Mere navvies these! Not over sober, perhaps, on Saturday nights! Rude, blustering pagans! And at Bugsworth! The very name is enough to choke a poet! And yet who of us would not take off his hat to the 'chaps' who, in the very mouth of death, went on with the work they had undertaken to do?

CHAPTER VI.

IN THE SIGNAL-CABIN.

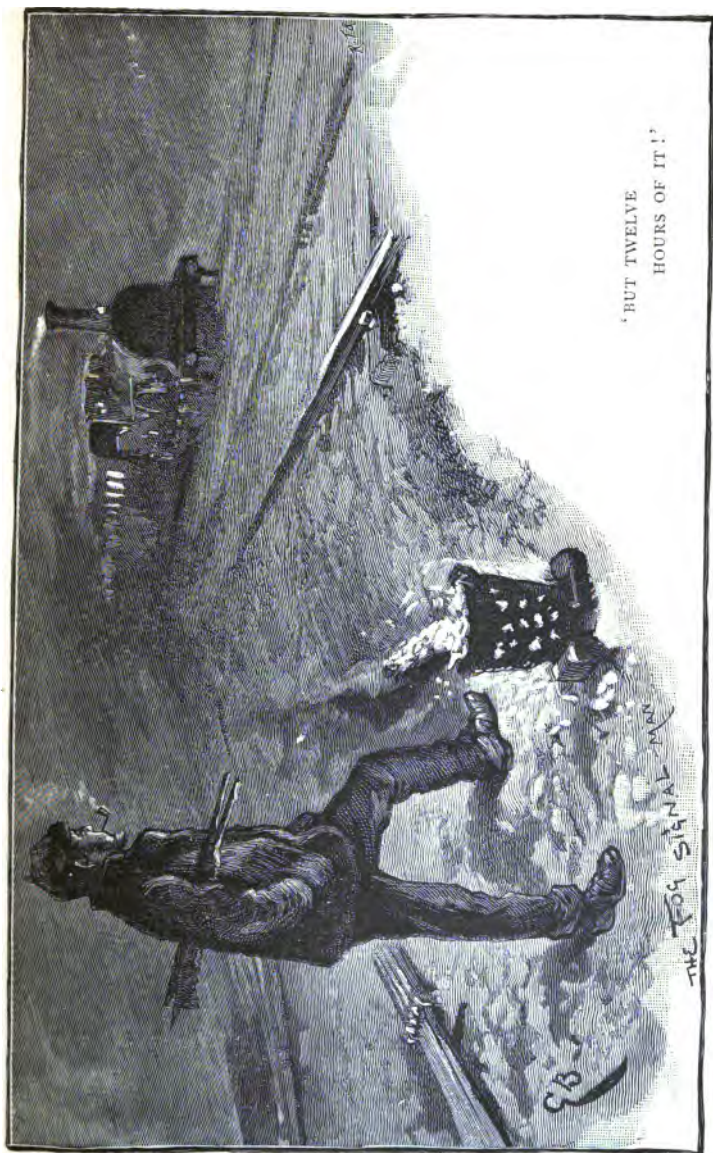
WHY does a railway man wear a red neckerchief? Answer No. 1, because he likes it; answer No. 2, because it comes in handy as a danger signal. Many a fatal accident has been averted by the timely use of one of those 'two red neckerchiefs yearly,' which form part of the porter's outfit. But there are times when the wisp of red is of no avail, and of such we had many examples during the last winter.

Riding one day in the front brake into Waterloo, we were suddenly startled by the flash and report of a fog-signal. 'Bang goes tuppence!' said the guard. And on inquiry we found that that was the value he put on these fireworks of the line. As several other twopenny bangs occurred before we passed under the famous A signal-box, we felt sufficient interest in the matter to undertake a small investigation, and as most of our fog-signals come from Kynoch's, of Birmingham—who are better known than loved among the grouse and partridges, except by those who appreciate sudden death—it was to Kynoch's that we applied.

'How many fog-signals do you make in a year?' 'Many thousands of gross are used by some of the great railway companies in the course of a winter. But the variation in the demand makes it difficult to give you the

'BUT TWELVE
HOURS OF IT!'

THE FOG SIGNAL-MAN



exact figures. We should say between one and two millions.' 'And this year?' 'It must have been nearer two millions than one!'

Two million rounds of ammunition! Nearly enough to mark out the entire equator in a series of cricket pitches, eighty to the mile. If the Flying Scotchman were to explode a signal at every revolution of her driving-wheel she would have to run on the Edinburgh road unceasingly for a whole week from Sunday morning to Saturday night before she had got through this little heap of detonators.

At the same time our guard was wrong in his estimate. Signals do not cost twopence each, but a pound a gross at the outside; but even at that price the total cost is considerable. A fog is an expensive incident to a railway company. In November and December 1890 there were 118,760 signals used on the South-Western. In January 1888 there was a fog on the M. S. and L. which used up 360 gross of signals, and cost £1,250, including of course the men's wages and food, for a 'fogger' on duty is fed at the company's charge. In the same fog the North-Western had men at 2,462 signal-posts doing nothing but attending to the fog-signals on the line.

As soon as a fog comes on the platelayers go off duty. Even if they could see the small patch of permanent way at their feet, it would be too dangerous for them to attempt to work. And so the platelayer appears in another character in the railway programme, and, in a thicker overcoat than usual, comes forth as a 'fogger.' A miserable occupation is his, but it is wonderful how cheery he can be under the circumstances. The fire, which as a rule he makes in a bucket, seems to give no more heat than a tinker's, and the shelter, when he has one, is rarely as wind-tight as a wattled hurdle; but as

you pass in the fog you may just get a glimpse of him smoking his pipe with commendable placidity, his only task being to interpret the sign language of the semaphore into the sound language of the detonator.

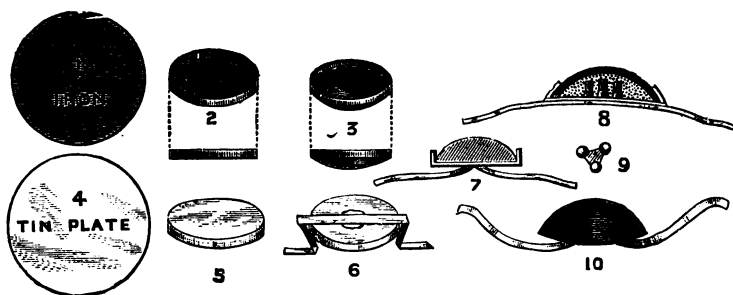
After three hours of duty he will get a cup of cocoa, or tea, or coffee, and occasionally something else. Then for six hours he will continue his gloomy watch until a meal arrives of bread and meat, and hot drinks as before. Then another three hours, and the relief man will come to let him go home to bed. It is great fun to let off one fog-signal, or even two—but twelve hours of it !

No wonder that every fog means more deaths among the foggers than among those who run the trains. It is not every man who can be trusted to do the work, and a lasting fog is a severe tax on a company, owing to the difficulty in finding reliefs from the ordinary staff. In one fog the Midland have had 4,000 men out along the line, and to keep up a number like that after three or four spells of twelve hours is not an easy matter.

The system of fog-signalling is simple enough. The man for the time acts as a semaphore. When the arm is up he clips a detonator on to the rail so that the train will explode it as it runs over it ; when the arm is down and the line is clear he picks up the detonator so that the train passes without a report. Sometimes two detonators are used, so that if one should miss fire the other may not ; sometimes one report means one thing, two reports another, three another. But under any circumstances there should be nothing more soothing to the railway traveller than the bang of the fog-signal. It is the fogger's ' All's well ! ' and shows he is at his post and alive to do his duty.

The signal he clips on to the top of the rail looks like a large button. It may be described as a gigantic percussion-cap, but it is really much more complicated. As

a matter of fact it has three caps besides the powder. There are four parts in a fog-signal : the dome, which is of sheet iron ; the base, which is of tinfoil ; the anvil, which is of malleable iron ; and the clip, which is of lead. The dome is stamped out of the sheet, and first appears as a two-and-a-quarter-inch disc, which is then cupped into the shape of a canister lid, and further developed into a basin. The base is stamped out of the tinfoil and begins as a rather larger disc, which becomes a canister lid, and then a lid with a deeper edge and just large enough for the little iron basin to fit into. On to the back the lead clip is soldered (Fig. 7). The anvil



THE ANATOMY OF A FOG-SIGNAL.

(Fig. 9), a triangle with a nipple at each corner, is cast in malleable iron and tinned, so as to prevent deterioration of the powder by the chemical action which would otherwise be set up between the powder and the iron.

The parts are then ready for loading. The dome or basin, which is painted inside in order to further isolate the charge, is filled with powder specially prepared for the purpose. The anvil on which the three percussion-caps have been fixed is placed in the powder, and the base is fitted on, and the whole pressed so firmly together under an ingenious machine that it is impossible for any of the

carefully-fitted parts to shift. All that the signal now requires is a little water-proofing and decoration. In the painting department it receives a coat of water-proof paint, and when that is dry it has another coat, and then it gets its label and finds itself packed with its fellows in paper cylinders. Being an explosive, it is, of course, carefully examined at different stages, and from every batch samples are taken, which are immersed in water to prove them watertight, and then fixed on rails in a siding, where an engine and trucks are run over them to ascertain if they explode quickly and with a sufficiently alarming report. One curious custom of the trade is that the companies make it a condition that the manufacturers should keep a large quantity in stock, so as to be prepared in case of a fog of long duration, and to keep this stock up during December is no easy task. Fog-signals are not always used in fogs. Not long ago a railway man was married, and twenty-one fog-signals were laid on the line as a salute to the bride at the 'going away.'

And now we are out of the fog we may as well return to that red neckerchief which we forgot to say was the first railway signal. As to which was the second there are several claimants, the most promising being the tallow candle which the Stockton and Darlington station-master stuck in his window when he wished the train to stop. On the Liverpool and Manchester in 1830 that candle had become a lamp and the kerchief had become a flag. In 1834 the pointsman's flag and hand lamp had found a resting-place on a post about five feet high. In three years the posts grew seven feet, and developed into twelve-foot standards with a disc instead of a flag and a piece of red glass in one of the lamp's faces.

Four years afterwards—that is, fifty-seven years ago—the present system of railway signalling may be said to

have begun. We have seen that 1891 was the jubilee of the railway ticket ; it was also the jubilee of the semaphore as applied to railway work. And, curiously enough, at the time it was so applied it had been in existence about fifty years. It was, in fact, the old original telegraph which gave its name to the numerous Telegraph Hills about the country. There is one of these telegraphs still at Portsmouth Dockyard ; there used to be one on the Admiralty in Whitehall, and on every prominent hill between the two points ; there was a series of semaphores all the way to Dover ; there was a series to the north. In short, the semaphore was the telegraph, and we still talk of the 'electric telegraph' to mark the distinction between the old fashion and the new. It was at New Cross, of all places in the world, that the first railway semaphore was introduced, by Sir Charles Gregory, in 1841.

To this signal there were no wires ; the pointsman had to stand at the post and work the lever with his hands. But five years afterwards one of those wonderful labour-saving Scotsmen, who have done so much for the world, found an opportunity of distinguishing himself. This particular Scot was a porter at Meadowbank, on the North British. He had two signals to attend to, and, finding it fatiguing to be continually walking from one signal to the other, he brought from home a length of wire and a pulley, and fixing on to the lever a broken chair as a counterweight, he hooked one end of the wire to the lever, and passing the other through the pulley he led the other into his hut and worked the signal by pulling and slackening it. Nothing could be simpler or more effective. Henceforth it was clear that a man could work a railway signal without going out of doors.

By and by Sir Charles Fox, whose enviable fate it was to drive the 'Novelty' at Rainhill and build the Exhbi-

tion building of 1851 and the Crystal Palace, invented the switch in replacement of the old sliding rail, and thus gave us the 'points' with which our signals now interlock. Interlocking really began about 1843, but it was not until Saxby's arrangement concentrated and interlocked the levers of points and signals at Bricklayers' Arms in 1856 that it can really be said to have come into practical use. On its further development we need not dwell.

Speaking generally, there are now two kinds of railway signals: those with a square end and those with a swallow-tail; the square-enders are 'homes,' the swallow-tails are 'distant.' The distant is merely a caution. When a home is against a driver he must stop; when a distant is against him he must be prepared to stop if he finds the home bars the road. By this arrangement there are saved in a year a good many minutes and a good many tons of coal, the caution being always given in time for the driver to get his engine in hand. On a level road a distant is a thousand yards from a home, on a rising gradient it is closer, but it is always far enough away for a train to pull up between the two.

There is only one side of a signal to which attention is necessary, and that is the side which faces the direction from which the train comes. Except on the Greenwich line and a very few others in this country, the rule of the road is the rule of the railroad—the paradox quite in which by keeping to the left the trains keep right. The signal arm therefore faces the driver on the left side of the post, and its face is painted red. It is the red side which clears or blocks the line, not the white. Another fact worth noting is, that for the purposes of safety it is assumed that danger is the normal state of things. Consequently, when a signal is at danger it is at rest. Then it is that the lever is down; to clear the line the lever

has to be pulled up, and the result is that down drops the signal to danger if the machinery breaks.

Railway signal making is a trade by itself, but of late the larger companies have been taking the matter into their own hands, and the visitor to Derby or Crewe with a general permit will find himself duly introduced to the semaphore in its different stages. At Crewe there is a shop nearly a hundred yards long and about thirty wide entirely devoted to signal fitting. Down one side are the posts in preparation, some of them fifteen inches square at the bottom end, with some seven feet of the timber left in the rough, charred in a furnace and soaked with gas tar, to preserve it from premature decay in the ground. Some signals are seventy feet high with a five-foot arm, but when the height is over forty-five feet there is generally an arm lower down, so as to be visible from the rail level in thick weather. The arm is of wood or corrugated steel, and on it is fixed the pair of spectacles with a green eye and a red one which, working in front of the lantern, give the colours that at night make our great junctions look like drug-shops.

A signal-box has been compared to a great church organ. We have been inside the organs at the Albert Hall and Crystal Palace, and we are inclined to think the state of affairs in a signal-box, and under a signal-box, is more complicated, though it is simple enough when understood. The general appearance is familiar—a row of iron levers on one side ; a row of telegraphic instruments on the other ; a clock, a desk, an open book ; a man or men at work with a boy or boys, amid a constant ringing of bells, clicking of keys, and jolting of springs; the levers like a set of teeth, complete when all are at danger, broken here and there when a few are at ‘line clear.’ Where the levers are not bright they are painted

of different colours : black, perhaps, distinguishing the point levers ; blue, the down signals ; red, the up signals ; green, the distants ; and in a large cabin the groups of these colours are perhaps the most conspicuous feature. The signal-levers, it is hardly necessary to note, have wires to work, the point-levers have rods either of iron piping or, as on the North-Western, of rods painted red. A signal, as we have seen, may be worked a thousand yards from the cabin ; points are never worked at a greater distance than the eighth of a mile. When the points 'face'—that is, when the train runs on to another line in continuation of the direction in which it has come—the length of the point-rods is not allowed by the Board of Trade to exceed 150 yards. When the train has to back, the points are said to 'trail,' and then the rods may be of the full length of 220 yards.

Every lever is numbered, and on every lever is a series of numbers showing those that are in interdependence with it. This is the key to the interlocking apparatus, which is under the floor, and consists of a sort of gigantic tumbler lock with sliding and vibrating bars working into notches on the lever. The signalman is by this arrangement prevented from opening the points to one line and giving a safety signal to a line that crosses it. He can probably send a train on to any one line, but he has to do so in a systematic manner. Once a train is beyond his signals, he has no control of it, and he is powerless when the train is travelling through the points, for, owing to the 'detector bar,' he would then have to lift the whole weight of the train. One would think that with all this mechanism collisions would never happen ; but happen they do, the accident being brought about, not by one pull of a lever, as is popularly supposed, but by the pull of half a dozen, all in due order and strictly according to rule. The truth is that all men are liable to make

mistakes, and the man most liable to do so is he who works long hours, week in, week out, at the one monotonous occupation. At the new Waterloo A cabin there are 236 levers, making as many movements in a twelvemonth as there are people in London, and averaging twenty-two movements for each train. To work these there are ten signalmen, four on duty from 7 a.m. to 2 p.m., four from 2 p.m. to 10 p.m., and two to complete the round; but in the country boxes—and on other lines—the hours are much longer and the work less incessant, so that the man has time to think of other things, while he becomes too jaded to pull himself together at a moment's notice. Hence mistakes, and elaborate mistakes, and disasters; very few though, fewer than in any other country in the world, but still too many. Signalmen are worked too long and paid too little, even in view of the future, when further automatic machinery will have further simplified their work. Like the great majority of railway men, they have no chance of receiving that gratuity for taking which they would never be 'instantly dismissed'; and, like them, they suffer indirectly from a system by which the porters before the scenes add so largely to their incomes. If the passengers, instead of 'tipping' the porters, would put their twopences into a superannuation-box, it would improve the position of the railway man all along the line. Tipping is a survival from the old coaching days, and beyond, from further back, in fact, than the days of lord and varlet. It dies hard, but the times are going when 'Fivepence an hour and what you can make,' and '16s. a week, and double it by tips,' will be accepted as a fair solution of the wages question even by the passenger porter.

The earlier signalmen were policemen, and as a survival from the old times a signal inspector is still known

amongst railway men as a P.C. To maintain the North-Western signals in order there are eleven of these inspectors, with a staff of 500 foremen, chargemen, and artisans. Every fortnight every cabin on the line is inspected, and has all its fittings cleaned and oiled and repaired, should repairs be necessary. There are eleven districts, each under an inspector, and these are divided into lengths, each under a chargeman, and in every cabin there is posted up the name and address of the chargeman responsible for it, so that he can be sent for, should any accident happen during the intervals between his regular visits. The steel rodding these gangs deal with in a fortnight would extend from Land's End to John o' Groat's, and the wires would span the Atlantic from Liverpool to New York. To protect the 1,800 miles of line they have to visit some 1,500 signal-cabins, controlling 17,000 signals, and containing 32,000 levers. Crewe turns out nine signals complete a week, including bracket and gantry posts, some of which carry as many as twenty-four arms, and the largest interlocking apparatus it had completed recently was that at Rugby South Junction, which contains 180 levers.

But we have by no means done with our signal-cabin. We have said nothing of the 'compensator,' which automatically makes allowance for the expansion or contraction of the rods from heat or cold; nor have we mentioned the 'adjuster,' by which the signalman can tighten or slacken his wires if they do not work easily; and we have omitted the 'key interlocker,' which is the most ingenious of the three. This is used when the points are too far from the cabin to be worked by rods, or when it is not thought worth while to go to the expense of rodding. The signals are worked by a frame of levers having a number of keys, and when the siding or branch line is to be used, a key withdrawn from the

frame locks the signals, and when carried to the junction unlocks the points. Once the key is in it cannot be taken out till the points are closed, and the signals cannot be moved till the key is taken back to the signal-box and replaced in the frame.

Then there are the 'starting' signals at the platform, to permit the train to enter the next section into which the line is divided; and there are 'advanced starting' signals at the end of the furthest siding, to stop the train going too far; and then there are the disc signals for the shunters, and other supernumerary signals, which are often of a different colour at night to those on the through track.

One difficulty in signalling remains unsolved. When there are two lights on a post, and one goes out, how is a driver to know which it is? The signalman knows; he can see the signal front or back from his box, and if he cannot, electricity comes to his aid. When a signal is out of his sight, he has a model of it in his box electrically connected with it so as to mimic every movement. Below the model semaphore is a small disc marked 'Light in'; above the invisible signal-lamp is a brass and steel tongue which, so long as the lamp is burning, keeps hot, and owing to the unequal contraction of the metals remains bent. When the lamp goes out the tongue cools and straightens, and touching a binding screw, makes an electrical current which rings a bell in the signal-box, and changes the 'Light in' disc to a red one marked 'Light out.'

And thus we have reached the telegraphic branch of signalling, to which the safety of our trains is chiefly due. The block system, now generally adopted, has been so often described that we can be brief. The line is divided into sections by signal-cabins. The signalman at any one

cabin receives a 'Be ready,' consisting of so many strokes on a bell according to the sort of train that is coming. If the line be clear he repeats the signal back, and in reply he receives 'Train on line.' The train passes the other signal-box and enters the section between the two. As soon as he receives 'Train on line,' the signalman sends on 'Be ready' to the cabin next in advance, gets back the repeat, signals 'Train on line,' and clears his bit of the road until the train passes, when he signals back 'Line clear' to the first cabin. In this way no two trains can be on the same section at the same time. In the 'permissive block' system two trains may be on the same section at the same time, but usually under such conditions as to make accidents improbable.

Those who have listened outside a country signal-box can pretty well tell what the different rings mean. On different lines they vary, but on one line, at any rate, one stroke of the bell means 'Attention'; two, 'Train on line'; three, 'Be ready for goods'; four, 'Be ready for passenger'; five, 'Be ready for express goods.' But telegraphic signalling will take us very far afield; suffice it to say that every company has its code-book, just the same as a cable company or any great mercantile house, and by the code much time is saved. When a station-master telegraphs that 'A hat-box and umbrella have been left in the net of the fourth first-class compartment from the end of the train,' he does not stop to spell out all these words, but 'codes' them up into something short, which would considerably astonish the excited owner of the lost property if he saw the telegram as received.

We are so accustomed to see our railroads with double tracks that we are apt to look upon the double track as the normal permanent way of the world. This it certainly is not. Colonial and foreign lines are usually

single, at which we may not wonder when we consider the lightness of the traffic; but it comes as a surprise to find that even in this island, out of the 17,000 odd miles over which our trains run, no less than 6,900 have but a single pair of rails.

In England and Wales there are no less than forty-seven companies having only single lines, of which the three largest are the East and West Junction, in the Stratford-on-Avon district, the Manchester and Milford, and the Midland and South-Western Junction, each of which is forty-one miles long. But these single lines are insignificant compared with the long stretches of doubles, trebles, and even quadruples of the better-known companies. In Scotland a very different state of affairs exists. There there are more single lines than doubles. Two companies in the north-west have nothing but single track. Most of the North British is single line; the Highland has only 10 miles of double out of 445; the Great North has but 49 out of 316; in short, it is only in the case of the Caledonian, the Glasgow and South-Western, and the City of Glasgow Union that the double track forms the bulk of the road.

The boxes and 'blocks,' and other arrangements for ensuring safety on double track railways are fairly familiar to the majority, but the single track routine is somewhat of a mystery, at least to a Londoner. How is it that trains in this country do not charge into each other, as they seem to do with such alarming frequency in the neighbourhood of classically named cities on American soil? How is it that a collision on a single line is the rarest of railway accidents? It has been suggested that if every train were to carry a director there would be no accidents at all—a rather rash assumption; but this carrying of a director, or his representative, was essentially the beginning of the single track system. According

to Sir Boyle Roche, 'man is not a bird; he cannot be in two places at once!' and the truth thus remarkably expressed is the motto of the single-tracker. At first an official used to travel on the trains passing backwards and forwards between each two stations on the line, and as he could not be on more than one train at a time, his presence on one train precluded any other train from entering the section of which he was in charge. It was, however, soon seen that the man could be replaced by something inanimate and cheap, and so he disappeared, leaving his 'staff' behind him.

This staff, once a gaily-painted stick of wood like a constable's truncheon, and now generally a brass casting, contained on it the names of the two stations between which it had to be carried. A train started from Sandown, for instance, and took the staff to Shanklin; at Shanklin the staff was handed to the driver of the return train and carried by him back to Sandown; and so the traffic went on—and still goes on—the staff travelling backwards and forwards, and no train being allowed to start without it. Given a staff for every two stations, and you have the single track system at its simplest, unless the simplest be when the company has only one engine to spare to work a 'shuttle' train to and fro between two stations.

But it may happen that the exigencies of the traffic require for a brief period more trains to travel in one direction than in the other; or a train may be wanted to start from a station at which the staff was not left the night before, or a breakdown may disorganize the traffic. What becomes of the staff then? Is it to be sent over the mountains on horseback, as it often is in Wales? The solution of this problem was discovered over fifty years ago by Mr. Henry Woodhouse, who was then in charge of the Stanedge tunnel on the North-Western,

his system being authorized by the Board of Trade in 1860.

This is known as the 'staff and ticket' system. The engine-driver is shown the staff by the station-master, and thereby knows that no train can be coming in the opposite direction on the section of the line along which he is to run. But, instead of carrying the staff on his engine, he takes a ticket giving him permission to travel. The driver of the next train is also shown the staff, and thus assured against collision, he likewise takes a ticket and starts; and so on, driver after driver, the last one taking the staff which has thus blocked the line against all trains except those travelling in one direction. The tickets are collected at the other station and put in a box, which can only be unlocked by the staff used as a key; and when unlocked the tickets can be used for the return journey, to be set free again when the staff arrives.

But even engine-drivers and station-masters may become careless. What is there to prevent a ticket being given when the staff is not at the station? 'Nothing easier,' said the inventor; 'let the tickets be of brass instead of pasteboard, and let them be locked into a hole in the staff, so that they cannot be issued unless the staff is at the station!' So far so good; but even that does not meet the difficulty of an emergency, or of the staff being at one station when it is required to begin business with at another. 'What is to be done then?'

The answer was given by one of the Caledonian men in the invention of the 'Tablet' system, now becoming general, in which the equivalent of the staff is electrically controlled from the other end of the section, so as to form a combination of the systems of the staff and block. At each station there is a box containing so many tablets, the boxes being in electrical connection. When a train is ready to start the signalman at the one station tele-

graphs the fact on to the next station, and the signalman there draws out a slide in his instrument and pushes down a plunger which makes a contact which enables the first signalman to draw out of the instrument at the starting station a small quoit-like tablet, which the driver brings with him as his authority to travel. The mechanism is such that not only can only one tablet be taken out at a time, but only one tablet can be missing from the boxes. Suppose, for instance, there are eight tablets, four in one box and four in another; then there must be at least seven tablets in the boxes for the contrivance to work; and if a tablet be taken out of one box it must be put back again into the other before another tablet can be released. The driver takes his tablet on with him, gives it to the signalman, who puts it in the box, and then only can the driver of a following train receive permission to start. The train is thus always under the control of the further signalman, who is unable to make a mistake owing to the lock on the boxes. Should at any time one of the boxes be empty, there is an end to trains coming towards it until the tablets have been brought back to it one by one, and it is in this manner, by taking advantage of the physical fact that a material object cannot be in two places at once, that safety on our single tracks is assured.

But this is not the only tablet in use on the railroad. On the outer wall of many signal-cabins there will be noticed an elliptical or diamond-shaped piece of wood hung on a nail. By the way this is hung the drivers, and others interested, know if the signals are working properly or improperly. Like the points and semaphores, the telegraphs are under constant inspection, but a failure in them is more quickly known. As a rule, the telegraph superintendent of a railway company knows the state of the whole of the line under his charge before ten o'clock

every morning. And the line is rather long if the wires be placed end to end. We know of one section of line on which there are sixty-one wires, but let us be moderate, and take ten as the average. That would give us 170,000 miles of telegraph wire on the railroads of Britain. Allowing six cells to a mile, we should have over a million cells to work them by, most of them Daniells, with Leclanchés for the bells, and Bichromates for the repeaters. It is curious how much the expectation of life for telegraph wire will vary. In the pure air of Anglesey a wire lasts thirty-five years; in the foul atmosphere of Widnes and St. Helens it lasts but three.

CHAPTER VII.

THE BREAKDOWN.

THERE is one train on the railroad to which even the mail has to give way. 'Keep a clear road for the express!' is the first maxim taught the aspiring lad of fourteen when he begins his railway life in the signal-box. And the second is of even greater urgency—'Clear the road of everything for the breakdown!'

It is with trains as it is with men and women, railway and otherwise. All have their daily work at stated times; all have to be considerably sorted out in cases of emergency; but in emergency, as in every-day work on the railroad, property yields the pass to life, either directly, as the goods train does to the passenger, or indirectly, as in the case of the food train, for which the local traveller must be shunted that the home-stayer may be fed.

At the strategic points, so to speak, of our chief lines, a 'breakdown' train is always kept in readiness. It is easily recognizable as it is passed at rest in the siding, being made up generally of seven vehicles with the crane in the middle. Protecting the crane, which is kept low enough to clear all the bridges and tunnels, there is a runner or waggon at each end, one of them carrying the jib of the crane, the other taking the balance blocks;

and these, with two tool-vans, a riding-van, and a packing-van, complete the group, which will often remain unused for months.

But it is always ready. Entering the riding-van, we shall find the stove prepared for lighting so as to warm the food and drinks; and the cupboards, which are crowded with tools, and flags, and fog-signals, and lamps, will have every lamp trimmed. In one tool-van we shall find short lengths of stout rope, and pulley-blocks and snatch-blocks, and levers and shovels, and screw-couplings and axle-clips, all in due order; in the other van we shall find an engineer's bench at one end, with two vices in position, and screw-jacks and other jacks underneath; and the packing-van we shall find loaded with pieces of wood from two feet to six feet long, varying in thickness from an inch to six inches, which will be used to form a firm foundation for these jacks when the breakdown gang gets to work.

That may be at any moment. The breakdown train is the fire-engine of the line, always fit for instant service, but when or whence the call may come nobody knows.

An accident happens, it may be fifty miles away; the telegram announcing the fact arrives at the junction or terminus where the breakdown is stationed, and two copies of it are sent off at once, one to the traffic superintendent, the other to the locomotive foreman in charge of the shed. On the office wall hangs a list of the crew who man the train, and off to them go special messengers. Soon they come hurrying towards the siding, often in the night time, dressing as they come, much as we have seen lifeboatmen making for the boat. The active but unfortunate staff-officer on 'emergency' duty, who can never take a walk from his registered abode without leaving a written statement behind him as to where he has gone and how he can be found, has meanwhile been

traced along his paper 'scent,' like a busy doctor or a hare pursued by a cross-country club ; and in the manner of the soldier who dropped the soup at the call to arms, the Queen's messenger on his bridal morn, and other oft-quoted celebrities of fact and fiction, has instantly rushed for the train, which by the time he is on board has loaded up with her regular crew, and as many additional men from the locomotive department as may have been thought needful. The nearest engine in steam comes backing out of the shed—there are instances of one having been requisitioned from a passing excursion—and in a few minutes the breakdown gang, in their travelling workshop, are on their way to the scene of disaster along a road cleared of everything on wheels—engine, coach, and truck, goods and passenger, stopping, fast, and mail, ordinary and special, and even of the Royal train itself, should it happen, as it has once done, to be barring a section of the track in its leisurely progress, at some junction where it is within reach.

The gang does not take long to get to work when it reaches the place of accident, its task being to save life and clear the line. If the time be night, or the place in a tunnel, the first thing done is to get a light, and around the wreck iron bars are driven into the ground, on which are hung the torches and naphtha lamps brought in the van ; and often fires are made of the splintered wood-work, or of any fuel that may be handy.

The crane jib is soon up, the balance blocks in position, and to give a firmer grip the crane is fastened to the rails with four clips, so that it is capable of carrying a much greater weight than its appearance would promise. Soon the wood packing is being handed about, and the screw jacks got to work ; and slowly, very slowly, the vehicle, or what remains of it, is lifted on to the line, or cleared away. If it be a case of mere lifting, a sort of iron

shoulder is fastened to the rail so as to stand up from its outer edge, and to stop the wheel from being forced over too far. But if it be a case of pushing or pulling into position, then the 'ramp' is used—a shallow triangular tray, hooked to the rail and spiked to the sleeper, up which the wheel can travel as on an inclined plane, until it drops with a jolt into its normal position. There are left-handed ramps and right-handed ramps, and double ramps, thick, clumsy things, looking by themselves like the coulter of some peculiarly powerful ploughs, and when in position like big flattened burrs on the rail.

But we need not dwell on the scene to describe it in detail; it is imaginable easily enough—the crane busy in charge of its five men, the blocks, and tackle, and jacks, and levers in full play, the dull hammering and straining, the occasional rattle, the clang of iron, most of the men gathered around—forty is the crew of the riding-van—some of them in the van at the bench, some going and coming within the hazy, flaring, flickering light of lamp, torch, and fire; and away in the darkness the solitary rear-guard, with his lamp, and flags, and fog-signals, barring the approach of all but those who come to help.

The breakdown gang has a free hand, but it is not always thanked for its work; indeed, it sometimes hears, after its work is over, that it might have been more merciful in its dealings with obstructions. Its object is to clear the road at all costs, and the results of its labours, as well as the causes which made its help necessary, are not unfrequently contemplated with regret. When new composite carriages, costing perhaps £800 each, are rolled down an embankment as being the quickest way of temporarily disposing of them, it is not to be wondered at that the feelings of their makers and owners are somewhat painful.

Fortunately the breakdown does not often go into

action. The fewness of accidents, in comparison with the traffic, is one of the most remarkable things in railway locomotion. And of these a very few result in personal injury. All accidents involving the least damage to life or limb are reported by the companies to the Board of Trade, who, whenever they think fit, send off one of their inspecting officers to view the scene, and hold an inquiry on the spot, such reports being annually submitted in summary to Parliament. Numerous as these reports appear to be in the aggregate, they are very few indeed compared with the opportunities afforded by the millions of miles run by British trains in a twelve-month; for, as we have said elsewhere, only one traveller in more than 90,000,000 is killed in a railway accident in a year.

That one fact sufficiently indicates why it is that the breakdown spends most of its days in the sidings. It can hardly spend them there too long. May its intervals of rest be greater and greater, but not too great to decrease its efficiency when it gets its call!

At the same time, our 'everyday life' would be judged incomplete without an accident, and so let us take say four examples of the very worst. The most terrible railway accident we have yet had in this country occurred about one o'clock on a fine August afternoon. The site was that part of the North Wales line between Rhyl and Colwyn Bay, where the rails run nearest the sea. On the shore close by is Pensarn; to the west is Llandulas station, the highest point of the line; to the east down a slight incline is Abergele station, from which the disaster received its name. Abergele itself is three-quarters of a mile inland.

The train to which the accident happened was the Irish Mail, which leaves Euston at a quarter past seven in the morning, and which up to this fatal day, August

20, 1868, had run regularly for eight years without the slightest breakdown. Thirty years have passed since then, and the Irish Mail still leaves Euston at the same time, and runs over the same bit of line at the same time, and the passengers watching for the glimpses of the sea are hurried along, little thinking of the tragedy that then sent a thrill of horror through the land.

From Chester to Holyhead is eighty-five miles. The line coasts the estuary of the Dee, turns off westwards near the Point of Air, and then coasts the Irish Sea to the Menai Straits, which it crosses by the famous tubular bridge, and thence runs on through Anglesey and Holy Island to Holyhead. The mail runs the full distance without a stop, leaving Chester about a quarter to twelve, and reaching Holyhead at ten minutes to two.

On the day of the accident the train consisted of thirteen carriages when it reached Chester. There some additional carriages were put on in front, so that when it started it was made up of the guard's van, a composite carriage, two first-class carriages, a luggage box with a second-class compartment, a post-office van, the travelling post-office, another post-office van, and then the carriages as they had come from London. In the first of these was the family of the then Lord Lieutenant of Ireland, the Duke of Abercorn. The Chester carriages filled up with passengers from that city; among them were Lord Farnham and his family, the Rev. Sir Richard Chinnery, Judge Berwick of the Irish Bankruptcy Court, and others we need not mention. The engine which took on the train was a very powerful and heavy one, the Prince of Wales, and the tender was one of the largest.

The mail ran out of Chester about eight minutes late, and went on steadily enough through Rhyl and Abergelle, and had just begun to mount the incline to Llandulas, when, as he ran round the curve, the driver saw, about

twice the width of the railway in front of him, a train of trucks, the nearest to him laden with barrels of oil. Shouting to the stoker, 'Joe! jump off!' he leapt for his life. As he touched the ground he was struck by a piece of the guard's van and knocked down the embankment. Hurt in head and hand and knee, he got up and went back to the train.

A goods train had preceded the mail, and was on the top of the Llandulas incline, shunting into the sidings. It was a very long train, much longer than any one length of rails, and it was being, so to speak, packed away in detachments. A few trucks were left on the main line while the engine took the rest away. These trucks were supposed to have the brakes on, as usual, and at the rate the express was running, there was ample time for the goods engine to pick them up and shunt them out of danger. The brake van had been taken off with the rest of the train, and there six trucks, the hind ones loaded with paraffin oil, stood motionless in the bright sunshine, as innocent an example of loaded rolling stock as can be imagined. The engine ran out from the siding and backed to pick up the trucks. The operation is familiar to all. The engine slows as it reaches the truck, and as the buffers meet, the coupling is slipped over by the man in waiting. The engine, then, slowed as it approached, and knocked against the trucks. The brake had either slipped or never been put on! The trucks shot back along the line, and away they went down the incline at ever-increasing speed to meet the mail, the man running after them in vain.

The shock was not as great as might be thought; but the heavy passenger engine smashed into the goods trucks, and rolled over, and the tender was shot right over it and fell in front. The weight of the engine and tender probably kept the carriages on the line, for not

one left it. It was not the collision that was so remarkable, it was its consequences. For the oil barrels burst with the shock and rolled round the engine fire and under the carriages, and in a minute the fore-part of the train was hidden in a curtain of velvety black smoke, which cleared into a vivid sheet of flame. Nothing could be seen for a time of the carriages in front of the post-office van; whether they were empty or not was not known, and the heat was so great that none dare approach them. The oil ran among the sleepers and the line was in a blaze. Not a cry was heard, not a sound except the roaring of the flames.

The driver ran to uncouple the London portion of the train, and the Marquis of Hamilton and other passengers jumped out to assist. As the fire reached the post-office the clerks threw out the letter-bags, while the leather connection and straps were cut away and the carriage backed out of danger. The glare of the flame had been seen at Abergele, and an engine came on to inquire. To it the train was attached and drawn away from the ruins.

The smoke was now clearing round the front part of the train, and giving place to flame, which rose in a sheet twenty feet high. As the inky fumes rolled away, the people could see with horror that human forms were in the doomed carriages, shrinking into ashes as the fire raged in and out of the holes where the windows were. For fifty yards the fire roared along the line; the gravel, saturated with the oil, seemed to burn like coal; the rails got white-hot and bent as they lengthened. The telegraph poles were burnt like straws and the wires fell into the fire; the hedge burnt, the grass burnt, the line was barred with the flame and its fringe of pitchy fumes; the heat and stench were awful. Approach was impossible; the carriages were left in the veil of fire. They dropped in together; the red-hot metal-work fell away;

and all that remained was a layer of ashes. At eight o'clock that night the line was still ablaze.

The driver was hurt, and one of the post-office clerks was slightly shaken. They were all that were injured. The rest were killed.

These were said to number thirty-three, but it was never really known. Only the merest fragments remained among the ashes; and none could say whether some had been men or women. All that was left of some were cinders which together would not have made up the size of a loaf. Among the ashes were the remains of twenty-four watches. Lady Farnham had with her six thousand pounds' worth of jewellery, and the stones were picked up from among the ballast of the line, some blurred, some untouched by the flames, the diamonds having stood the fire best.

The men from the Llandulas limestone quarries came down to help, and a few people from the coast joined them, and with the passengers made great efforts to subdue the flames, but all was in vain. The case was hopeless, the fire had to be left to spend itself at its will.

In Abergele Churchyard a huge grave was dug in which thirty-two coffins were laid side by side. The grave is railed in and bears an inscription, and those who are near the little Welsh town might do worse than give it a visit and read the sad memorial.

Abergele was the most terrible accident we have had in which fire played the chief part; a less fatal but much stranger affair happened at Welwyn in 1866. It seems, indeed, almost incredible that three trains should crash into each other in a tunnel and catch fire, and that the tunnel should be left for hours a huge furnace, with flames vomiting from its mouths, and leaping up through fifty feet of rock, to pour from the air-shaft in such volume as to redden the sky. And yet such was the case.

Welwyn is a pleasant Hertfordshire village, known in literary history as the place where Dr. Young wrote the *Night Thoughts* which have so many admirers. The railway is the Great Northern, which passes it on its way from Hatfield to Stevenage, leaving it about a mile to the left. There is first a tunnel, a quarter of a mile long, known as the South Welwyn, then a deep cutting a quarter of a mile long, then a tunnel three-quarters of a mile long, known as the North Welwyn. The country round is all chalk, but just on the top of these two tunnels come the spurs of one of those outliers of tertiary beds which are characteristic of the district, and prove the former existence over it of the newer rocks. The capping is, however, now very thin, and the fifty feet from the crown of the arch to the top of the shaft of the North Welwyn rises almost entirely through chalk.

A few minutes after the midnight of Saturday, June 9, 1866, there ran into the south end of this tunnel a train of thirty-eight empty coal-waggons, on its way to Hitchin. With the train were the engine-driver and fireman, and a guard named Wray, who had in his brake, unknown to the others, a friend named Rawlins, to whom he was secretly giving a 'lift' on the road to the North. The friend was in the brake against all rules, and dearly did he and the guard pay for their little conspiracy.

All went well with the 'empty' until it reached the middle of the North Tunnel, just under the air-shaft, when one of the tubes from the boiler burst, and so weakened the power of the engine that it could not draw the load. The driver, Sizer, sent back the fireman, Kemp, to explain to Wray the reason of the stoppage, and tell him to go back to the south end of the tunnel and give the alarm. This, however, the guard refused to do. On the contrary, he suggested, as they were on an incline—or 'bank,' as it is technically called—that

the train should be backed down the slope out of the tunnel. To go back on the wrong line is, however, against all rules of railway management, and the driver refused to do anything of the sort. His plan was to uncouple the engine, which was powerful enough to run by itself, and, leaving the trucks, make all haste on to Stevenage for assistance.

It so happened that the signalman at the south end of the tunnel had advised the man at the north end of the passage of the train, and, after allowing the usual interval, had telegraphed to know if the train had passed out, as another one was due. The signalman at the north end wired back that the train had not passed out, but the south man read the 'No' as 'Yes,' and shifted the signals to 'All clear.'

The down Midland goods train, of twenty-six heavily-loaded trucks, came along as he did so, and the driver saw the signals change from red to white, to give him a clear road. He dashed on into the tunnel. Kemp, the Northern fireman, had just uncoupled the crippled engine, when the Midland bumped into the guard's brake and sent the empty trucks flying off the line. Wray and the stowaway were simply smashed. The engine was capsized, and the trucks were thrown over on to the up line and piled up in heaps against the crown of the arch. Strange to say, the driver and fireman were not killed; they escaped with a severe shaking. Indeed, as if to point a moral, the only lives lost in the whole affair were those of the disobedient guard and his friend.

No sooner had Sizer and Kemp felt the bump of the collision in the rear of their long train, than an up train roared past them. This was the Scotch meat train on its way to London. In a moment there was an awful crash, as the engine dug deep into the wreckage of the other trains and added to it its own. Again were the

driver and fireman thrown off unhurt. But this time the fire from the engine ignited the oil flowing from the barrels with which the Midland had been loaded, and the flames broke out. The Midland driver and fireman ran to the south end of the tunnel; the Northern driver went off on the damaged engine to Stevenage, and the Scotch driver and fireman retreated in the same direction from the suffocating smoke and heat. Six-and-thirty carriages were on fire. The tunnel became a furnace. The flames mounted the air-shaft, and passed forth with a roar like that of a cataract, and from the tunnel ends came flashes amid the smoke that began to roll forth. Help came, but nothing could be done. The heat was intense. The explosions of the cases and barrels were appalling. The fire was left to work its fury out.

Meanwhile navvies were being collected from all parts to clear the line, and four hundred and fifty stood ready to begin as soon as the fire permitted. Then the Marquis of Salisbury sent on his fire-engine from Hatfield, and this was run into the tunnel. But where was the water to come from? Amid deafening whistling and screaming, engines came backing in with their tenders full, from which the fire-pumps were fed. As one tender was emptied it was run out to make room for another, and from tender to tender the pipe was passed, while the navvies, in gangs of fourteen, took turns at the pumps. Slowly the fire was quenched. At the bottom of the air-shaft it burst out again, and again more tenders were backed in, and the hose played upon the obstinate embers. Then the tenders were taken out, and the 12-ton accident derricks backed in from each end, and round the wreckage were bound huge chains and tackling, and bit by bit, sometimes in small masses, sometimes in large, the heap was dragged down. Often two engines would come puffing out of the tunnel dragging behind

them a huge catch of ironwork and charred wood. Again would the cumbrous fishing-rod be backed in and the line be cast, and, on Cleopatra principles, fitted with a fish, and out it would come trailing a shapeless bundle of springs and bolts, and nuts and rails, and telegraph wire and wheels, and screws and crowbars, and coke, coal, baked meat, wheat, and flour, all jumbled up together. It was more like clearing a choked sewer than a railway. What could be unhitched or unscrewed was unhitched or unscrewed. What had to be broken up was broken up. What could not be got apart was dragged out wholesale, scraping against the sides and crown of the tunnel, and tearing up the ballast of the way. The three trains had choked the tunnel for a hundred yards and more, and as two of them were heavily loaded with goods, the wreckage formed in places almost a solid plug.

The flames broke forth from the shaft in Harmer Green Wood, before half-past twelve on Sunday morning, and the county police thought they had discovered a volcano. The discovery was soon noised about, and from all quarters of the thinly-populated district the people were attracted to the light. As the day broke and the fire sank the crowds sought the tunnel ends, and at the Stevenage and Welwyn mouths stood watching the cranes coming forth with the hauls which the navvies, with crowbar and pickaxe, had prepared for them. Yard by yard the wreckage was cleared away, and over the ruined engines the gangs from each end met. Then the tough job of taking away the engines piecemeal began, and with the coming of the Sunday night the line was clear.

And now for another strange and startling accident we cannot well leave unnoticed which happened near Penrith, in Cumberland, in 1867. The London and North-Western Railway, on its way from Lancaster to Carlisle,

along the skirt of the Lake District, runs, it will be remembered, through Tebay Junction, Shap, famous for its granite, and Clifton, and then reaches Penrith, where tourists of the non-walking type change for Keswick.

It was along this lonely rocky road, about twenty minutes past eleven on the night of the 26th of February, that a goods train, having successfully mounted the Shap incline, went puffing through Clifton in that spasmodic way peculiar to goods trains. Amid the noise the axle of one of the waggons broke, but neither the driver nor guard was aware of the breakdown. On went the goods train puffing hard in the darkness; a long string of trucks with miscellaneous cargoes, some laden with salt, one laden with gunpowder.

Suddenly the truck with the broken axle slipped off the rails. Before the driver could stop, another truck followed suit, then another, then another; and as the engine slowed the hinder trucks ran closer and forced the forward ones across the 'six-foot,' and slewed them on to the up line. And fate so ruled it that the van with four tons of gunpowder was brought to a standstill immediately on the up metals. The train had so buckled as to barricade the line and throw its most dangerous element in the very front of danger.

Before the men in charge did anything to give notice of the danger in the path the roar of an approaching train was heard. Fortunately this was a goods train, and carried only three lives to lose. The driver, seeing no signal, and supposing the line was clear, came along at full speed, and dashed right into the powder van. Instantly there was a shower of sparks and a terrific explosion. One vast cloud of flame shot up and lighted the whole district. The explosion shook even the Lake hills to their centre; the hard earth trembled as if from the shock of an earthquake.

For four miles round the windows of farm-houses were broken ; and for twenty miles round the roar was heard, and the people came hurrying to know the cause. The driver and stoker were killed ; the waggons and goods were whirled about in all directions, and fell in heaps on each other.

From the engine fires they caught alight, and they burnt for hours, the heavy smoke-cloud hanging over the blaze and glowing red with its reflection.

As soon as they had recovered from their terror the four survivors—the driver and stoker of the train from the south, and the guards of both trains—took measures to stop the traffic north and south of the block. The explosion had occurred close to Yanwath Bridge. From there to Penrith is but a mile or so. The breakdown gang were soon on the spot, and by seven o'clock next morning the line was clear, but the wreckage piled by the side was left to burn itself out, and it took all day to do so.

At Welwyn three trains were wrecked in a tunnel ; at Abbots Ripton three trains were wrecked in the snow. At Welwyn there would have been no collision had the goods guard done his duty ; at Abbots Ripton, which was a much more serious affair, all the men did their duty, and the cause of disaster was beyond them.

It was a few minutes to six o'clock in the evening of January 20, 1876, when a coal train of thirty-three waggons ran out of the New England sidings at Peterborough on its way to London. At five minutes past six it was signalled through the Crescent all well.

The third week in January is the depth of the English winter ; in it we have the worst weather of the year. This particular day was one of the worst days of this worst week. The train left in the thick of a boisterous snowstorm : the snow drove fiercely and fell in such

huge, dense flakes that signals and signal-boxes were almost invisible. The air was so cold that the snow clung as it touched, and the trucks of the train, and the signal-boxes, and the signals were coated with white.

For eleven miles and more the coal train with its powerful six-wheeled coupled engine ploughed up the incline through the storm. The driver, Bray, and his fireman, with much difficulty, made out the signals to be in their favour, and the guard, Hunt, by frequently cleaning his window, and looking out, just managed to assure himself that a clear line was in front of him. At Abbots Ripton the coal train was to be shunted to allow the Scotch express to pass, and Abbots Ripton was safely reached. Bray there found the signals against him, as he should have done. The line was 'blocked' against an approaching train; and in opening the points for the coal trucks to shunt into the siding, the signals were all locked at danger—that is, so far as the signalman knew. The distance signal was nine hundred and fifty yards to the north of him, and he could not see it for the storm, but his levers were all back, and in his box the signal stood at block. But whether it was that the wires were interfered with by the snow, or that the snow had coated the red glass with a white veil, certain it is that a faint white light was all that could be seen by the train that was coming full speed to destruction. For all the signalman knew, however, the Scotchman was waiting till the distant signal was taken off; and as the trucks were being shunted down the siding he shouted out to Bray, 'Come, look sharp, you are stopping the express.' The twenty-fifth truck passed off the main line as he spoke, and before the twenty-seventh was clear, the Scotch express leapt into it at full speed. Striking the heavy coal trucks at an angle, the express engine glanced off on to the down line, dragging the tender and leading carriages along with it.

The shock was tremendous, but though many of the passengers were injured no one seems to have been killed. It has been suggested in grim humour that accidents would never occur if a director were carried in every train. It so happened that at Abbots Ripton each train had its director, and both of them were in the thick of the peril. In the Scotch train was Lord Colville, the deputy chairman of the company. In the midst of conversation he felt the carriage sink beneath him, and instantly he was shot out into the snow. Scrambling to his feet he looked around, and saw the wrecked train, lighted by the blaze from the scattered engine fire, which glared blood red and thinned off into purple haze amid the thickly-falling snow. The damaged carriages caught fire, and the snow turned to rain as it drove over them. Lord Colville and a railway traffic inspector, who was also shot out of the train, took the lead in dragging the injured from the shattered carriages; and Catley, the driver of the wrecked Scotchman, although his hand was crushed and the middle finger squeezed off, headed a few who strove to put out the fire.

Instantly it was decided to send the coal engine south to give the alarm. Hunt, the guard, rushed into the signal-box for formal permission, and found the signals all locked at danger. The signalman, Johnson, was confused, and no wonder; for in spite of his signals the train had come to ruin, and the unhurt passengers began to swarm into the box demanding telegrams to be sent for help.

The whole affair developed itself with bewildering rapidity. The coal train reached Abbots Ripton at 6.47; at 6.51 the collision had occurred, and Bray was off into the night on his undamaged engine bound for Huntingdon for assistance. With him went a telegraph clerk, also pitched out of the Scotchman, and Hunt, the guard,

returned from the signal-box. Six hundred yards from the scene he picked up his fireman, who had run south and put fog-signals on the down line. Everything seemed to have been done, and done quickly and surely, to protect the ruined trains. And all was in vain. Hardly had the fireman been picked up than there was a roar and a flash of light on the snow, and while Hunt waved his red lamp, and all on the coal train shouted, the Leeds express flew by, exploded the fog-signals, and vanished in the veil of whiteness.

There was a distant crash, and a shriek, and all was silent. On sped the coal engine to Huntingdon, with the red lamp waving over the six-foot. Another train was passed; and it was stopped in time. Huntingdon was reached, doctors were summoned and sent off in a goods train then ready in the station; and the breakdown gang was telegraphed for from Peterborough. The gang arrived at the north end of the heap of ruin at the same time as the doctors arrived at the south end from Huntingdon. There was much for both to do.

The Leeds engine, a splendid machine that had been one of the attractions of the George Stephenson Exhibition at Darlington, lay on its side up the embankment buried in the snow, crushed and battered out of recognition.

The driver and guards had seen the red light and heard the fog-signals, and put on the brakes; but the distance was not enough. The speed had been reduced from fifty to fifteen miles an hour, when the engine dashed into the ruined Scotchman, and literally climbed over the carriages and crushed them in. The Leeds carriages were swung round and over and among the scattered North-Eastern carriages and coal trucks; and an awful scene presented itself as again the engine fires flared fiercely and lighted up the snow, while in the storm gusts the heavy flakes were hiding the ruin.

In the Leeds train was Mr. Cleghorn, a director of the North-Eastern Company. He had his arm broken, and was dragged out by a North-Eastern superintendent, who was also in the train, and who, with a past President of the Society of Civil Engineers, also in the train, set to work to release the prisoners from their carriages. Helped by labourers from the cottages near the line, and by the rescued passengers of both trains, they soon had the unhurt, the wounded, and the dead cleared of the mass of broken wood and twisted iron.

The breakdown men found two rails knocked away and four others twisted up. Working through the night they had the up line ready for traffic at half-past seven next morning. The down line was ready an hour and a half afterwards. The medical report gave fourteen killed and nineteen wounded, as the result of the disaster.

There are some railways, notably one south of the Thames, whose service is invariably disorganized by a shower of rain; but the difficulties occasioned by so ordinary an atmospheric phenomenon have been overcome on most of our lines by simply providing a margin of engine power and brake power. At the same time, a little thought will show that the general slipperiness caused by wet must have a considerable effect on a railroad. To wet the rail is, in fact, in railway metaphor, very much like greasing a fiddle-bow.

But if rain is bad for the railway, what are we to say to snow? Snow in serious quantity comes on the average but once a year, and thus not quite often enough to permit of the sinking of capital to keep it off the line. It cost the city of London £5,000 to clear the snow from its streets after the greatest storm of recent years; the snowstorm of 1886 cost the North-Eastern Railway Company £100,000. But it would have cost more than £100,000 to build snow-sheds along the cuttings to

guard against future disaster ; and consequently the line, like other British lines, has been left open, and the snow is dealt with after, and not during, its fall.

The northern lines are naturally the greatest sufferers from snowfalls, but during the severe winters we have the southern lines are at least as much afflicted, and newspaper readers will remember the dismal tales of the Great Western and even South-Western passengers, who had to be dug out of the drifts.

Only those who have been in a snowdrift know what it means. On the bitter winter night the train rumbles along over the hardened masses that clog the rails as if it were running over that undesirable pavement known as petrified kidneys. On the embankments the furious gale sweeps everything clear in powdery spray, but in the cuttings the accumulation may become so deep as actually to push the train backwards every now and then, so that its advance is in a series of recoils and leaps, while the thickening cakes on the carriage windows mercifully prevent the passengers from realizing the danger in which they are placed.

Not long ago there was a snowstorm on the South-Western. About Whitchurch the powdery sea began to rise above the footboards, and soon the train came to a standstill. The ash-pan of the engine had become choked with snow, and, there being no draught, there was not sufficient heat to make steam. The guards and the stoker had to set to work to clear the white cake out of the ash-pan until steam began to be made again, but during the stoppage the carriage wheels had become clogged, so that, with the pressure in front and the increased load behind, the engine was powerless. From this trying position the driver escaped by a somewhat novel expedient. He uncoupled the engine, and literally charged into the drift for two or three hundred yards,

and so cleared a passage. Then he returned to the train, dragged it painfully along the cleared space, then wiped out his ash-pan, made steam, charged again for another quarter of a mile, returned, brought along the train, wiped his ash-pan again, charged again, and so on until he got through the drift, and resumed his laborious journey under more favourable circumstances.

On the Settle and Carlisle section of the Midland, in 1881, every device for getting through the drift was tried in vain; the train was snowed up completely, and only the top of the engine funnel appeared above the white waste, the top which a passing navvy is reported to have facetiously used as a spittoon, owing to the similarity of shape appealing to him so irresistibly. On that occasion the telegraph wires were a sight to see, the snow having accumulated on them to such an extent as to make them as thick as a man's wrist. In places the drifts in Cumberland were from thirty to forty feet deep, and out of them were dug ten cold locomotives, whose trains had been drawn away by fresh engines. The same storm cost the Great Western £56,000, that company having had to excavate 111 miles of snow from three to ten feet thick, in which were buried 51 passenger trains and 13 goods trains.

During the storm in March, 1886, a North-Eastern engine went northwards out of Gateshead, and began work by driving through a drift a mile and a half long and fourteen feet high, finally reaching a cutting where the snow had solidified into so compact a mass that the engine stuck fast; and from the Monday morning to the following Saturday night, none of the men at work to clear the road had their clothes off. For thirty-eight hours they were without water, except that obtained by melting the snow, and when at last the line was clear, and an engine slipped through to Alnwick for provisions,

the town was nearly cleared of meat and bread to satisfy them. That experience was a little too much for the company, and the result was the introduction of the North-Eastern snow-ploughs.

Passing along the line some time afterwards, we happened to see one of these ploughs. It was, and is, a sort of huge double coulter, or rather, a wedge with a midrib, mounted on an old engine frame, with a solid-looking carriage behind it, fitted with a cook's galley, and benches and cushions on which the men could sleep, belonging, in fact, to that obvious style of architecture in which the use of the thing is at once apparent from its shape.

There were at first two of these ploughs, and they did splendid service about Consett, in front of three engines, driving through nine feet of snow, and shouldering it off right and left much as the ram of a battleship cleaves off the water. So well did they work that two better ones, on a similar principle, were built, and it was one of these which wrought such havoc during the blizzard.

The second Scotch express, due out of Newcastle at 5.21 at night, had with two engines got as far as Morpeth, when it was deemed necessary to send it back, owing to there being no thoroughfare; and on its way back, on the up line, it stuck in the snow just north of Killingworth, that village so famous in railway story.

The plough was despatched to the rescue, with four engines behind it, and owing to the rails being so slippery and the brakes not acting, it not only ploughed up to the express, but actually ploughed it up. With its three hundred tons of engine weight behind it, it pressed on irresistibly in the darkness, at an appallingly deliberate crawl of about two miles an hour, wedging the front engine of the express up it, on to it, and over it; and it only stopped when the Scotchman rested on the funnel

of the first of its four engines. The carriage below was crushed in, and two of the occupants, one of whom was Mr. Wilson Worsdell, were seriously injured. In railway work it is the disaster which establishes, and since then we have heard little of the snow-ploughs, which do their work so well that they have ceased to be wondered at.

In America, where trains are snowed up every year, occasionally for a fortnight or more, the lines are protected by the snow-sheds, of which we have heard so much, and snow-ploughs are common objects of the track, but only a few of these ploughs are like ours. They are generally 'centrifugal excavators,' gigantic gimlets or augers, which screw their way into the drift, and spout up, so we are told, great pillars of snow, four feet through and sixty feet long; and so elaborate are these mighty machines that they cost £3,000 apiece to build.





UP CORNISHMAN LEAVING EXETER.
(From a photograph by F. Snary.)



THE OLD FLYING DUTCHMAN BELOW EXETER.

CHAPTER VIII.

ON THE FOOT-PLATE.

THERE are as many vehicles on the railroad in Britain as there are people in Gloucestershire, and as many engines to move them as—well, we cannot for the moment think of a town with 18,000 inhabitants, unless it be Taunton, which is not sufficiently well known for our purpose. These 18,000 engines, besides drawing over 50 tons a day apiece of minerals and goods, have each to drag some 1,300 passengers a day to or from duty, grief, or pleasure, and this they do with such safety and control that only one traveller in more than 90,000,000 is killed in a railway accident in the course of a year.

What the average speed may be can only be estimated,

but it is remarkable that the faster we go the safer we are. Trains have been classified into expresses and otherwise; expresses being such as average over forty miles an hour. Into the express group come more and more trains every year. All years are not equally free from accidents, yet there is a general tendency to decrease among the casualties, as there is a tendency to increase in the average speed.

How fast does a train travel? To average it is easy enough—so many miles from station to station, so many minutes running the distance; nothing can be easier. But this gives no clue to the speed at any portion of the journey, the laborious toiling up-hill, the free running on the level, the flying down the incline.

Last time we came out of the Box tunnel, a fellow-passenger informed us we were going 60 miles an hour. We were going fifteen. In about half an hour he again told us we were doing a mile a minute. So we were, and rather more, for we were going 65 miles an hour. It is curious what a charm there seems to be in this mile a minute, which is the rarest of speeds to run exactly. From Tring to Willesden, a distance of $26\frac{1}{4}$ miles, has been run in 21 minutes and even less, and one North-Western driver being 22 minutes late at Rugby has been only 11 minutes late as he passed Tring, and been in to time at Willesden, having run from Tring in 19 minutes, which is at a rate of over 82 miles an hour. When the Midland engines are tried in the silence of the night, they are worked up to 75 miles an hour, and on the North-Eastern there is one engine at least which has accomplished 86 miles an hour; but of course no train is run at this rate from stop to stop. If we want speed we must try the Caledonian, and even on that line the highest average is just under 61; though the 60 odd is obtained by an alternation of spurts and slows

varying with the gradient of the road. Taking the work all round, our fastest line is the Great Northern, whose best average is a little under $56\frac{1}{2}$; second in point of general speed is the North-Western, and third is the Midland.

Let us take our example of running from the Midland, so as to have something in reserve, in case we are accused of exaggeration. Here is the run of the Glasgow express between Leicester and Bedford on a certain day recently, as checked by the watch. In this section of the line there are fifteen stations—Wigston, Glen, Kibworth, Langton, Market Harborough, &c.—and working out the time between each with the distance between each, the rate of travelling between each came out at $34\frac{2}{3}$, 50, 55, $66\frac{2}{3}$, 72, $47\frac{1}{2}$, 58, 72, $79\frac{1}{8}$, 75, 78, 57, 52, 64, 63 miles an hour; total, $49\frac{1}{2}$ miles, done in 52 minutes 50 seconds, at an average of 57 miles per hour. This is not given as the best on record; it is probably a common achievement, and is merely a sample of what is done in every-day work on what figures show to be the third fastest line in Britain.

The driver knows the time he has to pass certain places on the line, not necessarily stations or stopping stations; and he gets his rate from his speed indicator or from the quarter-mile posts. Take the number of seconds you are travelling from quarter-mile post to quarter-mile post, and divide 900 by it, to find the number of miles you are travelling per hour. If the train takes 30 seconds between the posts, then 900 divided by 30 gives 30 miles an hour; if it takes 15 seconds between the posts, then 900 divided by 15 gives 60 miles an hour. The reason for this being that there are 3,600 seconds in an hour, which, divided by the number of seconds occupied in running a mile, will give you the rate; and therefore a quarter of 3,600

divided by the seconds occupied in a quarter of a mile will also give you the rate, with the use of fewer figures.

The building of an engine is much like putting together a puzzle, for the builder finds all his materials ready-made for him, and gathered to his hand from the different manufacturing shops. First he takes the frame-plates, which he places in their proper position on temporary bars. Then he adds to them the cylinders and foot-plate, and other notably essential parts of the skeleton. Then he lowers the boiler down to its bed. Then he lifts all he has built and slips under it the wheels and axle-boxes. Then what we may call the minor details are put in; the boiler is covered with the lagging, and the engine, lifted high up like a baby, is gently placed on the pair of rails on which it begins its life.

It is an exciting moment when the steam is first let into the new cylinders, and the completed engine is asked the question, 'Will you go?' Oftenest she does go, and, being found to run all right on the loose pulleys, out of the shop she comes, one of the ugliest objects that enter the world. The patchwork of bright and dull and rusty metal, the daubs of lead colour and pink and white smears make her seem about twice the size she does when decently clothed in her many coats of paint. And of coloured vestments she has to don not a few before she appears in her professional costume at a public platform. First comes a coat of lead colour; then two coats of filling; then she is stopped and hard stopped, and rubbed down; then she has two more coats of lead colour faced with pumice-stone between; and then she has two coats of the black, green, brown, yellow, or whatever it may be which is the distinguishing colour of the company to which she belongs. And with every coat she seems to get smaller and gain in good looks, until

she becomes graceful enough to gratify the critical eyes of a Stirling, a Johnson, or a Webb.

An engine is essentially a combination of fire-grate, heating-surface, and cylinders; and on the proportion which these bear to one another depends her power and efficiency. Being the outcome of at least as much practice as theory, her construction offers a wide field for individual opinion. No two builders make an engine alike in either design or material. A visit to a company's works, as at Doncaster, and then to other companies' works, as at Derby, or Gateshead, or Swindon, or Crewe, and then to a private establishment, such as Beyer's or Kitson's, will considerably open the reader's mind as to the number of changes that can be rung in a railway-engine on steel, cast-iron, forged iron, sheet-iron, galvanized iron, copper, bricks, gun-metal, asbestos, indiarubber, and wood. Yes, wood! and not oak, or ash, or elm for the framework, but unmistakable deal; and that inside the engine.

Go to Swindon, and you will learn that to keep the boiler and dome shielded from the outer air it is necessary for it to wear a jacket of non-conducting material, and that the non-conducting material there used is a cage of deal battens; so that at a certain stage in its growth a Great Western engine is 'bound in boards,' and looks as if it were packed for exportation. Over these battens comes the outer skin of sheet-iron, which bears the paint, and which to most people is the boiler itself. The use of deal is not confined to the Great Western; but go to Derby, and you will find the boiler coated with galvanized iron, and lagged with asbestos or silicate cotton under the outer barrel; and elsewhere you will find something different again.

In one corner of Derby yard there is a store of what look like bell-topper hats; these are cast-iron chimneys

upside down, with the wind-guard doing duty as a brim. In other works you will find that chimneys do not have wind-guards or caps, the idea that they turn aside the wind being laughed at; and probably you will find that the chimney is not made of cast-iron at all. But you must not believe all you hear. One company has the reputation of making its engines entirely out of cast-iron and lamp-black; but these materials are, of course, of the best quality, and, being mixed with brains, do remarkably well. Really, there is no engine which has not at least a dozen varieties of metal in its construction.

And there is no company which has not at least a dozen varieties of engine. Take the Midland, for instance, the 'pioneer line,' and the one most practical in its management. On the nine tracks which run through the huge 450 ft. erecting shop at Derby there will be found a dozen types among the nine dozen engines that are crowding there in all stages of construction. Here is a 'single-wheel bogie express,' working between London and Leeds, by way of Nottingham; it has $18\frac{1}{2}$ in. cylinders and 90 in. driving wheels. Here is a 'four-wheeled coupled express bogie' like the 'Beatrice,' which is the only engine with a name in the Midland sheds. Here is a 'four-wheeled coupled passenger tank engine,' for the Metropolitan work, with 63 in. driving wheels. Here is a six-wheeled coupled 'mineral' engine with 58 in. wheels; here is a 'standard goods' like unto it, but with $62\frac{1}{2}$ in. wheels; here is a 'six-coupled tank goods' with 54 in. wheels; and here is a short and useful 'four-wheel tank' for private siding work. Some of them ragged and fragmentary enough; some of them looking the picture of helplessness as they stand cocked up before or behind, hung to the tackle which is worked by the inch rope that gives the power by conversion

from the speed, and runs 2,000 feet a minute to lift a weight of five and twenty tons.

There are two chief kinds of railway engines—the simple and the compound. In the simple engine the cylinders are of the same size, and the steam is used only once; in the compound engine the cylinders are of different sizes, and the steam, after being used in one, passes into the other and is used again. In the Worsdell compounds there are two cylinders; in the Webb compounds there are three. The Webbs are used on the North-Western; the Worsdells on the Great Eastern and North-Eastern. A Webb is recognizable at a glance by the huge base of its low-pressure cylinder between the main frames in front, the connecting-rod working on to a single-throw crank in the middle pair of wheels; the high-pressure cylinders being outside the frames, between the leading and middle wheels, with the connecting-rods working on the trailing wheels. A Worsdell has the two cylinders in the usual position, either inside or outside the frame, though when they are inside one is generally higher than the other. In the engine we spoke of just now as doing her 86 miles an hour, the cylinders are of 20 and 28 in. diameter respectively, and the driving wheel is 7 ft. 7½ in. in diameter; when she ran her 86 she had eighteen six-wheeled coaches behind her, and was working at a pressure of 170 lbs. per in. The older engines have 18- and 26-in. cylinders. It was one of these (No. 117) which in the race to Scotland in 1888 did the last and fastest run, working up at times to 76½ miles an hour, and averaging over 57. The North-Western did not use their compounds to Edinburgh, the West Coast train being a light one; but they used them, and are using them still, on the Glasgow train, which is twice as heavy. It may be worth while to note that neither Mr. Worsdell nor Mr. Webb was the first

to build a compound locomotive; as far back as 1852 there were two such engines running on the old Eastern Counties, designed by John Nicholson, a driver in the employ of that railway; and although Mr. Worsdell is now identified with the North-Eastern, it was at the Great Eastern works at Stratford, when under his management, that the new compound first appeared.

It is claimed for the compound engine that it is economical to work, and gives greater power. The new Worsdells are said to save 14 per cent. of fuel; the Webbs are said to save 16 per cent., which is a consideration to a company like the North-Western, using over 1,000,000 tons of coal a year. Not only is there a saving in fuel, but there is a saving in water; and as an engine travels with over 2,000 gallons in her tender, and annually evaporates 8,000,000 gallons, the smallest percentage is appreciable economy. Even the saving of scale from these millions of gallons is of enough importance to encourage the Great Northern in stopping its trains at Grantham, where there is the finest engine-water in the world.

A Webb compound, such as the 'Marchioness of Stafford,' has a curious appearance broadside on, owing to the long slide, which looks like a new sort of coupling-rod, though, of course, the wheels are uncoupled. The coupling-rod, it may be well to point out, is the bar that works outside on two or more wheels and always remains horizontal—the bar, in fact, which the artist of a certain 'family remover' invariably paints as a fixture on the axle-boxes, and which to many people is the most characteristic part of a locomotive's motion. When an engine has none of its wheels coupled it is said to be a 'single'; when it has two pairs of wheels coupled it is said to be 'four-coupled'; and a large number of engines, chiefly used for goods traffic, are 'six-coupled.' And, while we are on this point, it may be as well to say that 'light

engines' are simply engines without a train; 'tank engines'—a very different thing—are engines without a tender, which carry their own water and coals, and are chiefly used for local work and station-to-station traffic. Long-journey engines have a tender which carries from 2,000 to 3,000 gallons of water and about five tons of coal. An express engine will weigh, say, 45 tons, the tender about 35—say, 80 tons the two—and as to cost, we can take the tender at £400 and the engine at five times as much. No wonder that the locomotive account runs into large figures, particularly at a place like Crewe, where a new engine comes out in replacement of an old one every fifth day; and where an engine can be erected complete, from the selection of the frame-plates to the going out under steam ready to work a train, all within $25\frac{1}{2}$ working hours; a job, however, which Stratford has done in ten.

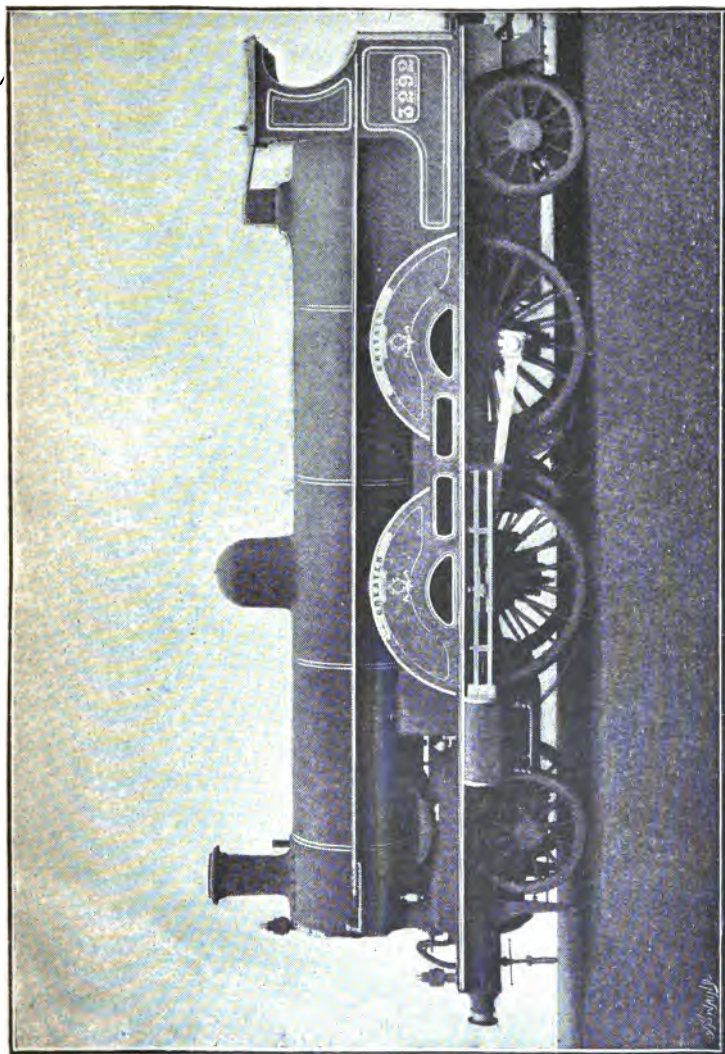
But we must have a typical engine, and in order to show what a complicated box of tubes and bars and springs it is, we cannot do better than give the particulars of that pride of Crewe, the 'Greater Britain,' which has nine big sisters like unto her. There are some people who revel in specifications; and those who cannot tolerate detail can easily skip a page or two. In 1896 these ten compounds ran over 462,000 miles at an average consumption of 38·3 lbs. of fuel per mile. Officially they are '7 ft. eight-wheeled compound passenger engines'; their details being:

Cylinders and motion :—

High-pressure cylinders (valve motion, curved link),
two, with open rods :

							ft. in.
Diameter	...	...	...	...	...	...	0 15
Stroke	...	...	...	...	...	...	0 24
Length of ports	...	...	...	...	...	...	0 11
Width of steam ports	...	...	...	...	...	...	0 1½
„ exhaust ports	...	...	...	...	...	...	0 5

	ft.	in.
Maximum travel of valves (piston)	0	4
Lap of valves	0	0 $\frac{1}{8}$
Lead	0	0 $\frac{3}{8}$
Inside clearance	Nil.	
Distance between centres of cylinders	6	6
Low-pressure cylinder (valve motion, single excentric):		
Diameter	0	30
Stroke	0	24
Length of ports	1	8
Width of ports	0	2 $\frac{3}{4}$
Width of exhaust port	0	5 $\frac{1}{4}$
Travel of valves (piston)	0	5 $\frac{1}{2}$
Lap of valves	0	1 $\frac{1}{8}$
Lead	0	0 $\frac{1}{8}$
Inside clearance	Nil.	
Length of high-pressure connecting-rods between centres	8	3
Diameter of crank-pin bearings (high-pressure) ...	0	4
Length " " " " ...	0	5
Length of low-pressure connecting-rod between centres	6	3
Diameter of low-pressure crank bearing	0	7 $\frac{1}{4}$
Length " " " " ...	0	5 $\frac{1}{2}$
<i>Frames:—</i>		
Thickness	0	1
Distance between frames	4	0
Length of engine framing over buffer-plates... ..	32	5 $\frac{1}{4}$
Width over foot-plates	7	7
<i>Wheels, axles, and springs:—</i>		
Diameter of leading wheels, with 3 in. tires... ..	4	1 $\frac{1}{2}$
,, low-pressure driving wheels, with 3 in. tires	7	1
,, high-pressure " " " " " "	7	1
,, trailing wheels, with 3 in. tires	4	1 $\frac{1}{2}$
Distance between leading and low-pressure driving wheels	8	5
Distance between low-pressure and high-pressure driving wheels	8	3
Distance between high-pressure driving and trailing wheels	7	0
Total wheel base	23	8
Leading axle (radial):		
Diameter at centre	0	6
,, bearings	0	6 $\frac{1}{4}$
,, wheel seats	0	7 $\frac{1}{2}$



THE GREATER BRITAIN.



	ft.	in.
Length of bearings	1	0
Centres of bearings	3	6½
Low-pressure crank axle:		
Diameter of bearings	0	7½
Diameter at wheel seats	0	8½
Length of bearings	1	1½
Centres „	3	2½
High-pressure driving axle:		
Diameter at centre	0	6½
„ bearings	0	7½
„ wheel seats	0	8½
Length of bearings	1	1½
Centres „	3	4½
Trailing axle:		
Diameter at centre	0	6
„ bearings	0	6½
„ wheel seats	0	7½
Length of bearings	1	0
Centres „	3	6½
Leading springs, laminated:		
Span	2	8
Number of plates, 16.		
Width „	0	4½
Thickness „	0	0⅞
Driving springs, high- and low-pressure, spiral:		
Two spiral springs 5 in. outside diameter, 1½ in. square steel coiled left-hand, with two internal spiral springs 3 in. outside diameter coiled right-hand.		
Trailing springs, laminated:		
Span	2	6
Number of plates, 13.		
Width „	0	4½
Thickness „	0	0⅞
<i>Boiler:—</i>		
Length of barrel	18	6
„ fire-box casing	6	10
Diameter of barrel (mean)	4	3
Extreme depth of fire-box casing below centre line of barrel		
„	5	1½
Thickness of barrel plates	0	0½
„ fire-box casing plates	0	0½
„ inside fire-box plates (copper)	0	0½

	ft.	in.
Thickness of outside plate of combustion chamber ...	0	0 $\frac{1}{2}$
„ fire-box tube-plate (copper) ...	0	1
„ combustion chamber tube-plates (steel) ...	0	0 $\frac{3}{4}$
„ smoke-box tube-plate (steel) ...	0	0 $\frac{3}{4}$
Number of tubes between fire-box and combustion chamber (copper), 156.		
Number of tubes between combustion chamber and smoke-box (brass), 156.		
Diameter of tubes outside ...	0	2 $\frac{1}{2}$
Length between fire-box and combustion chamber tube-plates ...	5	10
Length between combustion chamber tube-plates ...	2	8 $\frac{1}{2}$
Length between combustion chamber and smoke-box tube-plates ...	10	1
Diameter of chimney at bottom ...	1	4
Height of centre of barrel above rails ...	7	10 $\frac{1}{2}$
Heating surface :		
Fire-box ...	120	6 sq.ft.
Combustion chamber ...	39	1 sq.ft.
Tubes (front) ...	853	0 sq.ft.
„ (back) ...	493	0 sq.ft.
Total ...	1,505	7 sq.ft.
Grate area ...	20	5 sq.ft.
Ratio of fire-grate area to heating surface ...	1	: 73'4
Pressure of steam ...	175	lbs. persq.in.
Weight of engine in working order :		Tons cwt. qr.
Leading wheels ...	12	16 0
Low-pressure driving wheels ...	15	10 0
High-pressure „ ...	15	10 0
Trailing wheels ...	8	6 0
Total ...	52	2 0

On the 'Greater Britain's' experimental trip in November 1891, she had 25 coaches behind her, and she consumed only 34 lbs. of coal per mile, and evaporated 5,896 gallons of water, or 10'96 lbs. of water for every pound of coal. With her own weight, a tender of 25 tons, and a string of coaches weighing 305 $\frac{1}{2}$ tons, the moving mass totalled out to a weight of 382 tons and more. The ratio of the weight of the engine and tender to the train was as

1 to 3'96, and including the engine and tender there were 82 axles in the train, which ran from Crewe to Euston in 4 hrs. 2 mins., including a stop of 21 mins. at Rugby. Engine and tender measure 54 feet over all, and the coaches of the trial train measured 880 feet, making up a length of 934 feet for the 382 tons to be distributed over. So heavy a train had never before been hauled at such a speed, with so low a consumption of coal, the average rate of burning being 1,500 lbs. an hour, or 73 lbs. per square foot of grate area.

The travelling weight of engines and tenders has increased so much of late owing to the distances it is now found convenient to travel without a rest. In 1888 the North-Western began running its Scotch mail from London to Crewe, 158 miles, without a stop, and the Caledonian took the West Coast trains on from Carlisle to Edinburgh, $100\frac{3}{4}$ miles, from Carlisle to Glasgow, 102 miles, from Carlisle to Larbert, 110 miles, all without stops. At the same time the Great Northern was running the East Coast mail between London and Grantham, $105\frac{1}{4}$ miles, and the North-Eastern was running the $124\frac{3}{4}$ miles between Newcastle and Edinburgh. Now the Great Western is at the top of the tree by running without a stop from Paddington to Exeter, which is 194 miles. According to the customary definition, speed is said to be 'express' when it is over 40 miles an hour; but there are now thirteen British companies running trains that average over 50 miles an hour; the three of the 'great fifteen' who have not yet passed the 50 limit being the Chatham, the Brighton, and the South-Eastern.

The Midland engines travel the 124 miles between Nottingham and St. Pancras in 143 minutes, taking 200 tons over a ruling gradient of 1 in 120 at a consumption of coal of 20 lbs. per mile, which is one of the notable things in our railway work. Last time we were at Derby

one of the 'singles' to run this road was in the shop, brand-new, and just ready to move off to business. The contrast between her and the one we described when remarking on the ugliness of the thing of wheels and patches before she was passed as fit for service, was startling. New railway engines are familiar objects in exhibitions; here was one just ready to go to an exhibition, if needful, with all the latest improvements—steam blast to drive the sand on to the track, side-lubricators with steam-blast so as to be oilable from the foot-plate, &c.—the metal as bright as a new gold watch, and the paint as brilliant as a sheriff's carriage.

But for a thoroughly workmanlike, elegant engine there is nothing to beat one of the old Northern eight-footers. She rises so well on her bogie in her black and green livery; her 8-foot driving wheel (it is 97 in. really) seems not an inch too large for her length, and, with the trailing wheel, completes the curve so as to make her stand firm and light, and as though she would never leave the rail even when flying along it like the wind. Our engines get longer and higher, in order to enlarge the boiler capacity for long-distance steaming; and the longer and higher they get the better they stand these huge driving wheels which are apparently so much appreciated by the crowd.

But how about the men who drive them?

'How are engine-drivers made?' we asked.

'Sir, they are born.'

'Quite so, but—'

'It is not every man that will make an engine-driver.'

And yet the occupation seems easy enough! What can be easier than turning a tap of some sort, looking ahead, and rushing through space until it is time to turn the tap off again? That is all that engine-driving means—to the majority. What difficulty, therefore, can there be in finding fit men to look ornamental on a foot-plate?

But the majority may be mistaken! When we come to know a little more about engine-driving we find that it is not quite so simple as we thought. In the first place, an engine is almost the living creature that her driver calls her. Every engine has her whims and peculiarities; and no two engines, built alike in the same shop from the same plans, have ever yet been found to behave alike. In the next place, the driver is the captain and look-out of a travelling engine-room; he has all the engineer's duties to fulfil in addition to attending to the state of the road. Every 'beat' of his engine—four beats to every revolution of the driving-wheel—must be true in time and sound; every rattle and shake must be accounted for; every curve and gradient requires special treatment; every change in the force and direction of the wind will tell its tale if provision is not at once made for it. There are 9,500 parts in an engine, and 7,500 in a tender; in short, there is not a nut or tap that may not at any moment require to be seen to; a slight slip or breakage may happen, which if not dealt with instantly may wreck the train.

It seems but a matter of signals to take an express from station to station to the minute. But something else is required, and the very slightest want of attention on the driver's part may cause delay or disaster. When an engine has finished the day's work it goes to the shed to be cleaned inside and out by the boys; then the fireman or stoker comes on duty, and takes it over and gets his preliminary work done; last of all comes the driver, whose duty it is to inspect the engine all over before he goes to take up his train. Let him pass but one screw carelessly and he may come to grief. And this keen watch on bolts and pins liable to snap or slip he must keep up through the day. Think of the rate an engine works at. A seven-feet driving wheel going only forty miles an hour makes 160 revolutions a minute.

A man suited to drive the mail, or the Queen, is not to be found every day!

This driving of the Queen is the blue ribbon of engine-driving life. Days before arrangements are made, and very elaborate they are. The engine is not only inspected by the driver, but by the locomotive superintendent in person, and every fastening, inside and out, is tried and tested. Every station-master and signalman on the line knows the very minute the train will pass him. The pilot engine runs the course fifteen minutes exactly in front of the royal train. Between the passage of the pilot and the passage of the train nothing is allowed on the line, the points are all clear, and are even locked back so that nothing can get on the way. On the engine is a time-keeper watch in hand, seeing that every signal-box is passed at the time given on the programme; and though the driver has the chief officials of his company behind him, he is not interfered with, or even spoken to, so long as this time is kept. The man who drives the Queen is a good man—a man who is as much master of his engine as if it were one of his own limbs.

The thorough control some men have over 'the thing of cranks and wheels' was never more clearly shown than in an accident to an express some years ago. Suddenly the pin of the coupling between the engine and tender jumped out, and, while travelling fifty miles an hour, the engine darted off away from the train! The driver was on the engine, the fireman was on the tender. The fireman was about to put on the brake and stop the train.

'Leave her alone!' shouted the driver; and without stopping he gradually brought his engine back, and, without a stop or a blow, so managed matters as to keep engine and tender close together until another pin was put in and all made secure. And this while running, and getting the train home to time! No one would have

known of this extraordinary feat had not some labourers in a field seen the engine leap away from the train and then come back to it. The labourers talked about it, a station-master happened to hear of it and reported it, and the driver was called to account.

‘Why did you not report it?’

‘If I had done so it would have made a fuss, and given such a lot of writing work!’

Even the guards in the train were unaware of what is one of the most astonishing performances in locomotive life.

All drivers are not like this one. As an example of the other kind, take the happy-go-lucky individual who backed to his train and caught sight of the travelling inspector on the platform. The driver was so interested in watching which carriage he got into that he paid little attention to his proper work. The signal to start was given, and off went the engine. As the driver ran alongside the first platform at which he was to stop he saw a porter sweeping leisurely with a wide broom.

Leaning over, he gesticulated with his thumb, and kindly shouted as a caution to the leisurely porter, ‘Look out, he’s with us!’

‘No, he ain’t,’ said the porter, ‘for you ain’t brought no carriages with you!’

The driver had been so interested in the inspector that he had forgotten to make sure that his engine was coupled on!

His start from the station was a bad one; but how did he start in his trade? He began, as all the rest do, as a cleaning boy. At every engine depôt are so many boys, who take over the engines as soon as they come in from their work. They empty the firebox, take out the fire-bars, clean and scour every part of the machinery, destroy every trace of dust and dirt, and polish up everything that

should be bright. On the engine and in the engine they soon come to know all its parts, and in time are sorted out, the sharp from the stupid, and chosen to fill vacancies as firemen. As a fireman the lad begins work on goods trains and shunting engines, and is generally employed where he can do least damage. As a fireman he has to manage his fire so as to keep up the necessary head of steam without undue consumption of fuel or water. This is not so easy as it appears. Engines have their whims, coal has its obstinate fits, and weather no man can control. A method of firing that will suit an engine one day may not suit it the next; and as the cricketer has to watch the ball, and not the place where the ball ought to be, the fireman has to watch the fire, and not content himself with taking it for granted that all is well. His shovel ought rarely to be still; *Paulatim*, little by little, is his motto; he has to obey the driver's orders regarding forcing and damping, to keep things tidy, and to have eyes all round him. From a slow goods he goes to express goods; from express goods he goes to local passengers; from local passengers he goes to slow passengers, and at last he becomes fireman of an express. All through he is kept up to his work by a system of fines. If his fire is too feeble he is fined; if his fire is too fierce he is fined; if he saves coals and at the same time secures efficiency he is rewarded.

At last he is promoted, and becomes the driver of a slow goods; and from that position he works his way, step by step, as vacancies arise, until he becomes the driver of a mail train, doing his three hundred miles a day, and drawing his three half-crowns for each trip out and home. Those Londoners who wish to learn 'all about engine-driving,' as many seem to do, should go to the Camden depôt of the London and North-Western Railway, and prime themselves beforehand with Mr.

Michael Reynolds's *Locomotive Engine-Driving*. The London and North-Western have altogether some 2,600 engines; in this depôt at one time only some forty may be seen. These are enough. Some of them have just come in from work, besmeared with dust and dirt, others are bright as jewellery, ready to go out. To feed them with water there is a well nearly five hundred feet deep; to feed them with coal there is a staging down the side from which the four-ton tender loads are shot; and there is a huge furnace from which the shovelfuls of flaming coal are taken to give the engine fires a start, for all engines are lighted with live coals.

When the fireman arrives to take over the engine from the cleaners, there are usually but three inches of fire on the bars, and steam is feeble. He tests the water in the boiler, and looks at the pressure-gauge to ascertain the steam, and then proceeds to arrange his fire so that when the engine comes into the station on duty the steam is at the proper pressure, and none has to be blown off to waste. The perfection of engine management is to bring the engine in for the train without the slightest sign of steam about the safety-valves, and yet not to lose a minute during the trip, and this can only be done by driver and fireman working well together, and each attending to his own business. After the fireman has got his part of the work ready for a start, the engine-driver arrives, and takes over the clean, bright, eager baby in whom he takes such pride. For a driver is always proud of his engine as being the nearest thing to living that we know. Think what the inventor must have felt when for the first time he saw something he had built up move of itself from one place to another! What were all previous inventions to that! 'Make us something that will move of itself,' said the ancients, 'and we will believe you!' And now it is made, and the cry

is changed to, 'Make us something that will think of itself!' which is not so easy.

What a change these last few years of the world have wrought! Go to South Kensington and see the old pioneers with which the battle of movement was begun; or, as you run into Newcastle Station, look out at the bridge end, and behold old Puffing Billy with his spider legs, and compare him with the big-wheeled Worsdell going past. Puffing Billy was but a tortoise compared to her! And an expensive tortoise too, for we have not only gained in speed and endurance, but have saved in fuel and have improved in handiness.

And what fascination there is in engine-driving! Who has not felt his fingers itching to get but one touch of the regulator, and turn on the steam for once in his life! But which is the tap to turn? Alas! it never tells you in the text-books! And this is an omission that once almost led to a disaster at the expense of those diligent students, the Japanese. A merchant steamer came into Yokohama, and was bought as she stood by the Japs. The captain offered to leave somebody on board to show the new owners how things were arranged below. No. 'It was all in the books!' And the English cleared out to a man, and left the Japs in possession. Next morning they could see that something was wrong on the new Japanner. There was 'a mighty movement' on her decks, a running to and fro as though raving madness had attacked her crew. What did it mean? At last a boat came off. Would they kindly send an engineer on board? They did; and the engineer found that the fires were full on—as per text-book; the steam was up—as per text-book; and was still going up—not as per text-book; for the Japanese knew everything except how to turn on the steam! The text-book did not say which was the proper tap to turn, and the duly

certificated students were in mortal terror contemplating a safety-valve they could not move, and a pressure-gauge that told them every minute might be their last!

Even dogs have felt the fascination of the engine. There used to be a bright little English terrier that travelled regularly from King's Cross to Doncaster seated on the tool-box. Hail, rain, or sunshine, the dog would be seen sticking to his post while the engine dashed along at full speed, and the wind she made brushed out his coat till it looked as if made of bristles.

And then there was, of course, Snatchbury, the prince of drivers' dogs, whose adventures have been told at length by Mr. Reynolds. Poor Snatchbury! One day he came into Euston Square, dodging about on the platform, evidently looking for a friend. The engine came in, and the driver, best known as 'the Duke,' from his aquiline nose, caught sight of the dog, and called him. Here was a friend assuredly; and the little rough-haired, small-headed lump of yellowish caninity jumped on to the foot-plate, and scrambled up to the back of the tender. Off went the train, and with it went Snatchbury, as he came to be christened. And for ten years afterwards, by night and day, through fog and sunshine, Snatchbury stuck to 'the Duke,' and with his shaggy hair blown back so as to show his white teeth, hardly ever missed his engine. Every day he would come on duty and race down the engines in the shed till he found the right one, and if it had been moved he would leap and whine till it was pointed out to him. One day he came too late. His master was just going out; but Snatchbury was an observant dog, and waited till the next engine going the same road started, and then he jumped on her and went to Rugby, where he changed engines to Bletchley, and there picked up his master!

Snatchbury's intelligence was remarkable, and he had an observant master, who duly recorded it.

The dog learnt the signals, and could tell whether they were up or down, or red or green ; and if a red light was shown ahead he would announce the fact by a warning bark. Even the fog-signals he came to know the meaning of, and he would emphasize only the danger ones ! In fact, Snatchbury took an intelligent interest in all that he came across, and seemed never to forget what he saw. And he was a kind-hearted dog too. Often would his little face be seen on the engine at Euston leaning over and looking along the train ; and if he noticed a strange dog being put into the brake by the guard, down he would get, and run in to the stranger to see that he was comfortable, and doubtless assure him that it was all right, as 'the Duke' was the driver !

But one dreadful night a signalman at Harrow made a mistake, and showed the line all clear when a goods train was in the way. On came 'the Duke' in obedience to the signal full speed into the trucks he could not see. He was killed. Snatchbury was hurled off with him, but was unhurt. The dog's grief was heart-breaking, nothing for a time could console him. At the funeral the most touching sight was the tearful little dog following next to the coffin. When he went home it seemed as though he would die of grief ; but a pious fraud was resorted to, and the driver's boots were placed by the fire, as though ready for him when he came back. And with his nose between his paws poor Snatchbury waited, till he slept, for the master he was never again to see. After a time Snatchbury recovered somewhat and took to another driver ; but it did not last long. And now he is in a glass case with a label for an epitaph.

There was a time when the driver worked by contract, and found his own coal and oil. The driver of the

Flying Scotchman would smile at the suggestion now, although not the least of his objects are to keep time and save the coal and oil—prosaic duties for the man in command of the East Coast Flyer. And he is the responsible man, notwithstanding all the theories and respectabilities about the importance of the guard. How often does the guard of the mail touch the brake in these quick days? Hardly ever. How often is he ‘sorting’ when anything goes wrong? Generally always. As a matter of fact, the modern system of long runs and few stations throws all the responsibility on the driver.

He must travel by sight and sound. Every bridge and tunnel and bank and cutting has its peculiar note, and what the bells are to the signalman these sounds must be to him. Above the piston’s rhythmical beat, and amid the roar of the wind and the hiss of the rain, he must hear the whiff or rattle or clangour or boom that tells him where he is and the speed at which he runs. The rail may be damp, the coal may be poor, the wind may be high, but he must keep time. And his eyes must be all round him—on his indicators and gauges, on the road, on the signals ahead. It is no light responsibility to be in charge of a body of 200 tons moving at the rate of 90 feet per second!

And yet it all comes in the day’s work; but what that work is, and the overwork, it is not so easy to say, for any statement as to the hours a railway man works requires as much qualification as one regarding the wages of the agricultural labourer.

Of late there has been a general shortening of railway hours of labour. It has, for instance, been authoritatively stated that on the Great Eastern, out of a total of 538 signal-boxes, 73 are eight-hour boxes, 119 are boxes in which the signalmen are on duty under twelve hours, and the remainder, or 346 boxes, are rated at twelve

hours for each signalman. The twelve-hour men now work seven days one week and six days the next, and are off duty the seventh day every alternate week, practically getting a holiday every fortnight. The hours of passenger guards on the Great Eastern are sixty-six hours to the week of six days, any excess over that being paid for, but they do not habitually work on the seventh day. Shunters and pointsmen are on duty eight hours a day at important places, and at less important places for twelve hours a day. The hours of duty for goods guards are sixty-six hours for a week's work of six days ; and all overtime beyond that is paid for at the rate of 6*d.* per hour for head guards, and 5*d.* per hour for under guards. As a rule engine-drivers have a maximum of twelve hours per day, but in some instances the time, including intervals, runs up to nearly fifteen hours a day. And other grades have been considerably reduced as to their hours of duty in relation to what they used to be a few years ago.

We left our Northern driver on the foot-plate, ready for his ride to York. There he will take his engine into siding to make room for the North-Eastern compound, which will continue the run to Berwick, where the North Britisher will come into possession and distribute the train beyond the bounds of punctuality. Of course there is much to be said in excuse of this inability to keep time north of the Tweed ; there are difficulties, but the difficulties being of regular occurrence, and not of the nature of catastrophes, might surely have been dealt with before now. The general policy seems to be the making of it as difficult as possible to get out of Scotland, and the taking of the varnish off all the good work done south of Berwick and Carlisle. The wicked baronet who found the word Basingstoke so soothing to his agitated mind, would have appreciated the tale of those mushrooms at Waverley. When waiting wearily for the

move, what hundreds have been told of the disused tunnel in which those mushrooms grow, and how thankful they have felt that so unexciting a subject of conversation should be provided by the forethought of the railway company !

But let us be off to Perth, and after a trial of its baths and dressing-rooms, enjoy the famous salmon breakfast, and then go out on the platform and watch the start of the Highland express. This is the most astonishing train in the island, and the strangest of monsters to meet as it comes climbing round a hillside with two engines in front and one behind. The way in which trains are made up south of the Tweed—on the London and South-Western, for instance—is puzzling enough ; but how the Highland ‘harlequin’ gets together is a mystery. Here are from thirty to forty vehicles, representing, perhaps, a dozen companies—vehicles of all sorts, horse-boxes, carriage-vans, luggage-vans, saloons, composites, sleepers, all higgledy-piggledy—North-Eastern and North-Western and Great Western, North British and Midland and Brighton, Chatham and Dover and Great Central, North Stafford and Highland and London and South-Western, as if the agent of a firm of carriage-builders had come travelling north and brought his samples with him. No wonder that the Scottish trains are late when the staff to handle all this is insufficient ; and no wonder that the three great north-going English lines are held accountable for the delay.

One great line we have that to a certain extent is independent of connections, and can consequently keep its own time. That line is the Great Eastern, and its punctuality is proverbial. It is a rising line—it had a good depth to rise from—and it is going ahead in many ways. Its introduction of the compound engine we have noted ; now it is experimenting on fuel, and drives its

engines with petroleum. And thereby hangs a tale. In making the oil-gas for lighting the carriages a thinnish tar is left as a waste product. This tar was run off by the company into a Stratford stream. Down came the local authorities on the polluters, and the tar had to be got rid of in another way. How? Mr. Holden, the locomotive superintendent, took to burning it in stationary fires, and from step to step advanced until he could use ordinary oil and run 'a liquid fuel express.' In this new kind of firing a thin layer of coals is kept on the bars, and on to this the petroleum is squirted in spray from steam injectors; the tender having two tanks, one for water, one for oil. The tanks at Stratford, from which these oil-burners get their supplies, are almost as prominent as the huge heaps of coal stored in preparation against future strikes, and which it is hoped will long remain untouched.

A railway strike rarely succeeds because, in the first place, however low may be the wages and long the hours, the work is constant; the man knows what his work and pay are to be before he joins, and on every line are certain funds and superannuation allowances which put the service on much the same footing as the police and army and navy. On the North-Western, for instance, the salaried officers and clerks have their fund, the members paying sixpence in the pound on their salaries, and the company contributing the same amount as the members; the workmen at Crewe have a society of their own, and the engine-drivers and firemen and others of the running department have another society, and as the membership of these two societies exceeds 15,000, the locomotive branch is amply provided for; there is also the General Insurance Society to which every member of the wages staff except those mentioned above has to belong, the boys with wages under twelve shillings a

week paying a penny a week, the passenger guards and brakemen paying threepence, and the rest of the men twopence, the company adding five-sixths of the sum subscribed by the men, so that its income exceeds £30,000 a year; and there are the Provident and Pension Societies, now amalgamated, also with an income of £30,000 a year, due to the company's contributions and the penny or twopence a week from the men. As with the North-Western so it is with all the other lines, but as a rule the funds are special to different departments. The locomotive men have always their fund, but porters and more or less unskilled labourers are occasionally left out in the cold, not seldom owing to a percentage of them being of too limited a mental capacity to support anything but a 'fighting' organization.

But enough; and yet one sentence more. Over and beyond these private funds there is a society which deals with all railway men irrespective of their employers, and is open to public support; this is the Railway Benevolent Institution, on the Board of which are all the leading officials of the different lines, and which distributes over £14,000 a year in pensions and gratuities; and if any readers have been indebted to these chapters for taking some interest in those who earn their living on the railroad, they cannot more appropriately clear themselves of that indebtedness than by sending a guinea for the fund to the secretary, at 57 Drummond Street, Euston Square.

APPENDIX.

CHRISTIAN WORK ON THE RAILWAY.

THE details given in this volume abundantly illustrate the demands made on workers in connection with railways. The ceaseless run of the trains day and night means that a large number of men must turn night into day, and be prepared, on sudden emergencies, for even greater sacrifices than is implied in this, which is also common to other occupations. At one time, owing to the real or supposed exigencies of the case, railway men were left very much to themselves, so far as *religious* privilege and provision were concerned. And many, no doubt, were inclined to say, 'No man cares for our souls.' Specially in connection with the lines where Sunday excursion trains have been made a great feature, terrible revelations have at times been made in regard to over-work, and almost entire absence of consideration on the part of railway managers.

There have been earnest, religious-minded men in connection with the management of railway enterprise all along, but the plea of 'necessity' has often sufficed to stop any attempt to ameliorate the condition of the men who had little time, week in and week out, to call their own. Of late years all this has been changing, and railway men are regarded as having souls to be saved, and bodies which have more than merely machine-rights.

The machines in great factories have their appointed times for cooling, cleaning, and repairs, and at length these necessities are being conceded to the men who work the great system of railway enterprise.

Of all the agencies which have been established to bring some light and blessing into the lot of the railway man, perhaps none has proved so successful as the Railway Mission, started a few years ago. But so far back as 1857 Derby seems to have been the first centre, and the Midland the first railway where a distinct religious work was founded among the men employed. Here, at Derby, a few men used to meet in a workshop, running shed, or open yard to eat their breakfasts. As the winter came on they obtained leave to gather in the engine-room of the Methodist driver of one of the stationary engines. This George Wilkins was a 'zealous, godly man, ever ready to speak a word for his Master,' and with the men's leave he read a chapter from the Word of God and offered a brief prayer. Soon the engine-room was too small, and the open yard became again the rendezvous. Then the Locomotive Superintendent gave leave to meet in one of the workshops, and finally the Directors of the Company built a commodious hall in 1877. A little before this the men had begun to ask various ministers of the town to come and speak to them, and they started with the Rev. Joshua Walmsley (George Wilkins' pastor). Then followed men of the type of Dr. Tait, Bishop of London, Rev. C. H. Spurgeon, Canon Stowell, Bishop Lonsdale, Bishop Ryle, John Ashworth of Rochdale, Archdeacon Farrar, Rev. Dr. S. G. Green, and scores of similarly distinguished speakers. Breakfast and address go on at the same time, and then when plates and cups are empty, the eager assembly join heartily in a song of praise at the close of the 'breakfast-talk.'

The arrangements are under the guidance of a Committee, with the Chief Clerk of the Department as Chairman, and Mr. Joseph Scattergood as Honorary Secretary. The latter gentleman (one of the workers himself) has been the organizer of a great magazine department for the supply of healthy literature all over the Midland works. The extent of this may be judged by the fact that of one periodical alone, *The Cottager and Artisan*, fifteen hundred bound volumes are annually sold.

The Railway Mission has branches all over England, with twenty-three paid missionaries and evangelists, who are largely supported by the gathered contributions of the men themselves. The objects are best set forth in the report presented at the great gathering in Exeter Hall.

'1. To preach the Gospel to the *employés* on all lines, by means of accredited Evangelists holding special Missions at large centres, and the establishment of weekly meetings for prayer, Bible-study, and evangelistic addresses. 2. To help those who profess to be Christians to make known the Gospel to their mates, by a consistent life and by personal testimony. 3. To advocate the cause of Temperance, the care of the injured, and the moral and social well-being of all grades, and to assist in every way the various Societies already existing on our Railways. 4. To circulate *The Railway Signal* and other Christian literature.'

To some it may seem that in a book on the railways of Britain any account of Christian work may be superfluous. But the fact remains that directors and managers of the lines are beginning to see that fruit is borne by these efforts, which tends to show that travelling becomes all the more safe, and that greater economy is ensured, because the spiritual, moral, social, and physical welfare

of the men are more directly cared for and encouraged than hitherto.

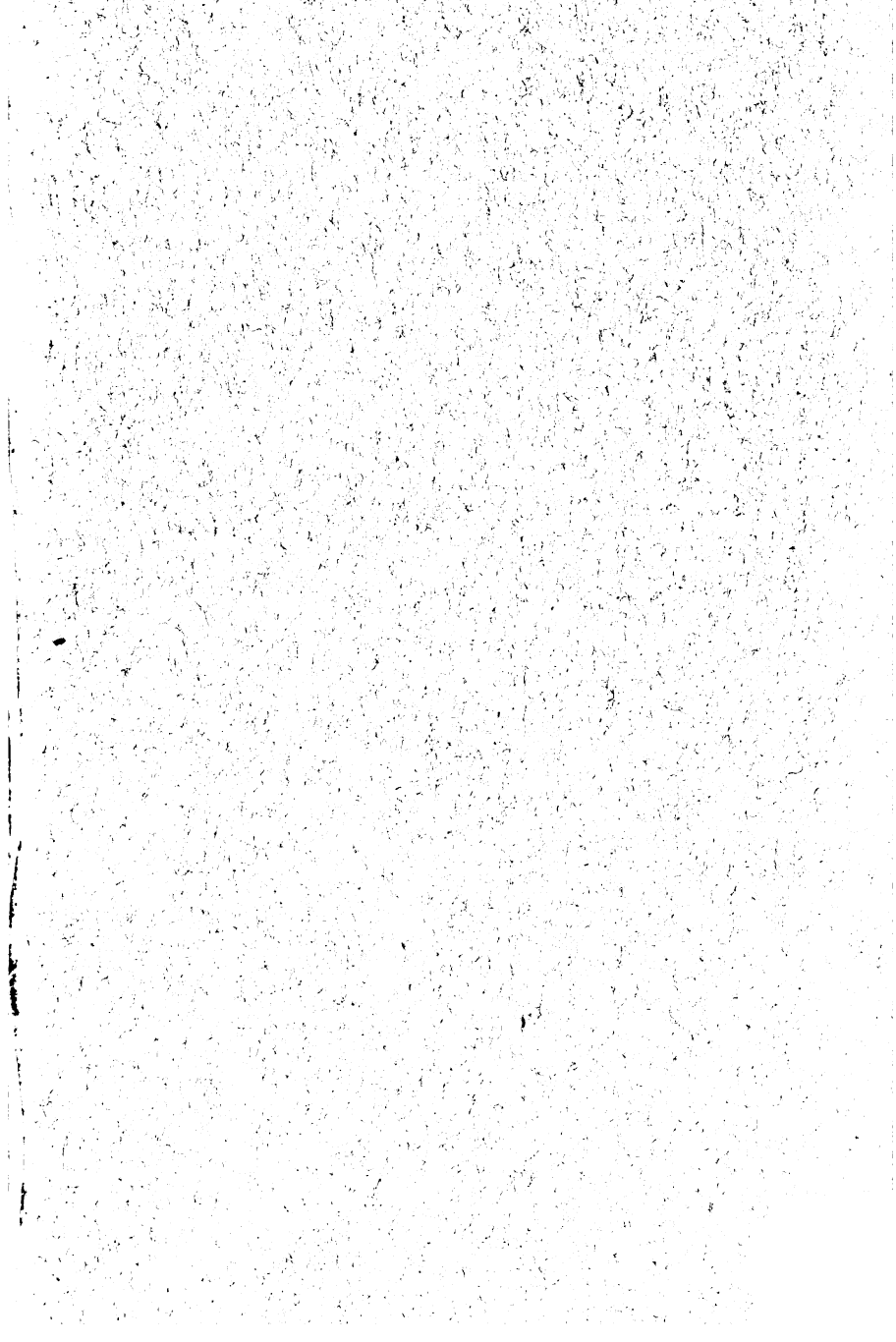
To this kind of religious work has been added a Convalescent Home at Hastings, with a department for the supply of artificial limbs, &c., for those who are so unfortunate as to be injured. A capital monthly periodical of their own, *The Railway Signal*, forms the medium of communication between the various departments of the work, and is one of the most readable of the special organs of its kind. 'Thorough,' and 'out and out' seem to be the watchwords which govern its manly and straightforward utterances, and one of the writers who attends to the 'points' certainly does not lack clearness of vision and pith in his columns. Here are specimens:—

'John the Baptist was a pointsman. He pointed to Christ, and cried, "Behold the Lamb of God, which taketh away the sins of the world." But his pointing would have been useless if his listeners had remained unmoved. They *heard* John, and then *followed* Jesus. That was how they got the blessing. You, too, my friend, will get the blessing of sins forgiven, and heaven sure, when you turn from men to *Christ Himself*. But you will not get it a moment sooner, try as you may!' . . .

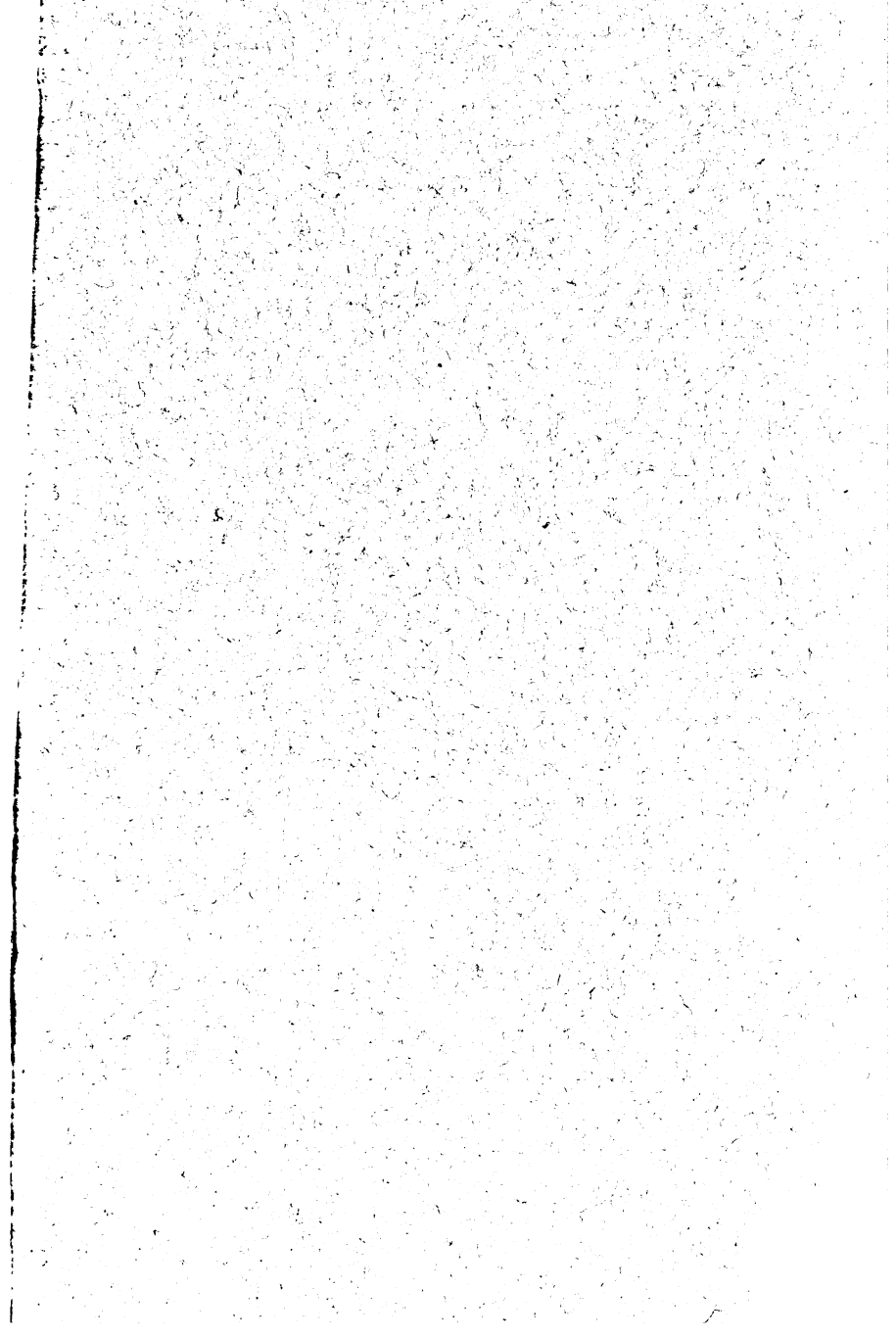
'Here is a signal which faces us in early life. "Remember thy Creator in the days of thy youth." Yet how many rush past it into manhood, unconverted. Here is another, too often unheeded, "Be sober." Alas! how many run by that signal into all excess of drink or lust. Later on, if warning after warning is neglected, there comes into view this solemn caution, "My Spirit shall not always strive with man." And if that too be recklessly disregarded, what remains?'

Sometimes one of the men will tell in simple but eloquent language the story of his conversion. An engine-driver writes:—

‘It was a Glasgow driver who advised me to go and see what a Railway Mission meeting was like, and the first night I was rather pleased with the homely way in which everything was done. I was asked to go back earlier the next Sunday and see the 5.30 meeting. I did so, and when I entered the room, I saw a sight I had never seen in my life before—six or eight men on their knees praying for the salvation of their mates on the railway, with as much earnestness as if it were for their own. I tell you it made me think. Here was I a man with a large family, the eldest fourteen years old, and never yet had they heard me pray for one of them, or thank God for a bite He had given me. I felt ashamed of myself, and amazed at God’s long-suffering mercy with such a careless, thankless sinner, as I now saw myself to be. At the close, one of the men I knew asked me why I was not a Christian—was I not willing to accept God’s offer of salvation through Christ? I felt my real state too keenly to say no, and when he suggested that we should pray together, I dropped on my knees beside him, and for the first time in my life I knew what it was to pray. The Lord’s blessed promise, “Him that cometh to Me I will in no wise cast out” (John vi. 37) was given to me. I flung myself upon Him, and, praise God, He took me, and for over three years has kept me, and He says, I’ll never perish, for none can pluck me from His hand (John x. 28). Not only has He saved me, but, bless His name, He has also saved my wife and several of our bairns. How can I keep from praising Him! Oh, man, give yourself to Jesus, and you too will know what real happiness is. He will take you, for He says, “*Whosoever will*” may come.’







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